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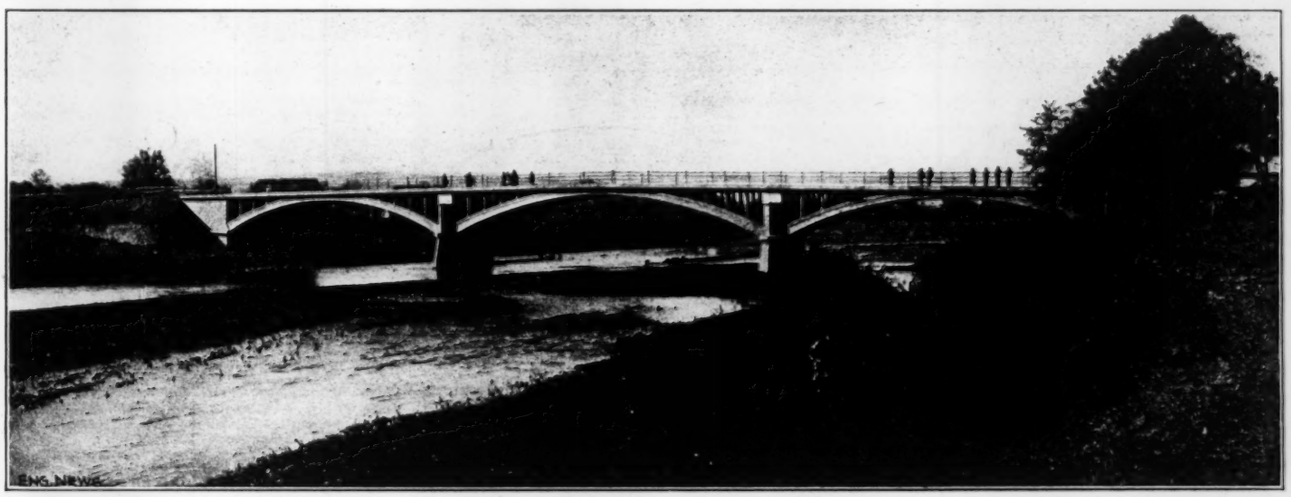
TWO AUSTRIAN REINFORCED CONCRETE ARCH BRIDGES.

One of the striking differences between European and American reinforced concrete arch bridge practice is the general employment in Europe of ribbed arches with open spandrels. There is, so far as we know, no open spandrel ribbed arch bridge of any considerable importance in the United States, while in France, Germany and Austria and, in fact, all through Europe they appear almost as frequently as do plain arch, solid spandrel bridges. As an indication of this tendency in Europe toward the imitation in reinforced concrete of the light, open forms of steel arches rather than the solid, massive forms of stone arches, we illustrate in the accompanying cuts two bridges recently completed in Galicia by Mr. M. Morssen, who has furnished us with photographs and brief descriptions.



RIBBED ARCH BRIDGE AT KROSNO, GALICIA.

The bridge shown in the larger engraving is located in Krosno, Galicia. It consists of three arch spans of 72 ft., 75 ft. and 72 ft., carried on two piers 4 ft. thick at the springing lines and 6 ft. thick at their bases, and on two abutments all of cellular construction. In general it may be noted further that the bridge, including abutments, is 257 ft. long and is 21 ft. high from water surface to roadway level.

Each span consists of four ribs 18 ins. thick and varying in depth from 12 ins. at the crown to 32 ins. at the springing line and each rib is reinforced by twelve 1-in. bars. These arch ribs carry 7 × 7-in. spandrel columns whose tops are connected across the bridge by 7 × 9-in. beams. Supported on these beams and in one piece with them is a 6-in. floor slab. The arch ribs continue through the piers and back into the abutments in the form of vertical diaphragms, which are braced laterally by transverse vertical partitions and by the enclosing walls. The vacant space between ribs and walls in both piers and abutments are filled with a lean concrete. The walls and partitions of the piers rest on slab footings, which are carried on open caissons sunk 12 ft. below the river bed.

In designing this bridge the stresses were calculated on the assumption of a dead load made up of the concrete at 140 lbs., filling at 120 lbs. and broken stone pavement at 90 lbs. per cu. ft. The roadway was designed for a live load of 20 lbs. per sq. ft. and a continuous string of 16-ton road cars. The maximum unit stresses exclusive of temperature stresses allowed in the concrete were 420 lbs. per sq. in. The reinforcing rods were proportioned to take all tensile stresses without being stressed more than 19,000 lbs. per sq. in. All reinforcement was iron. The bridge was built in 70 days and cost about $10,000.

The smaller view shows a bridge at Nowy Sacz, Austria. It consists of two 90-ft. spans which with abutments and piers make its total length 210 ft. The piers and abutments are solid concrete without reinforcement. Each span consists of two arch ribs 4.5 ft. thick and varying in depth from 15 ins. at the crown to 34 ins. at the springing lines; each rib is reinforced by twenty 1-in. round rods connected by 1-in stirrups. The ribs carry columns which support the slab and girder floor platform. This bridge was built in 3½ months and cost about $16,000.

THE ENGINEERING AND TECHNICAL SOCIETIES OF THE UNITED STATES AND CANADA.

For some years past there has been kept in the office of this journal a card index of the important engineering societies of the United States. Several requests for information concerning these societies have led us to compile from this card index a list of these societies with the name and address of the president and secretary, and wherever we were able to obtain it, a statement of the number of members.

We have included in this list both the societies of national scope and the local societies. We have excluded all the local clubs in the engineering schools, associations of their alumni, etc., and also the purely trade organizations such as the National Founders' Association, formed to deal with labor matters, and various mercantile and manufacturing associations which handle trade matters alone. We have included, however, such societies as the National Electric Light Association and the New England Cotton Manufacturers' Association since their proceedings often contain matters of technical interest.

We have held to an alphabetical arrangement for convenience of reference; but it will be readily seen that a classified list might easily be prepared which would for many purposes be more convenient and useful than the list below. The first broad distinction to be drawn is between the national organizations and the local organizations. The latter frequently combine with their technical work more or less of the features of a social club; and we have in fact included some organizations such as the Engineers' Club of New York and the Cosmos Club of Washington which are nothing but social clubs. As their membership is largely made up, however, of engineers and men interested in engineering work, we have deemed it useful to include them in the list.

It need hardly be said that the societies in the list vary enormously in their standing and importance, ranging from the great National Societies devoted to Civil, Mechanical, Mining and Electrical Engineering, with many thousand mem-

bers, large property and high technical standards to the societies in which membership is little more than nominal, which are organized to further some reform or special line of work.

The compilation of this list has required a great amount of correspondence; and particulars as to officers and membership are still lacking, as will be noticed, for a considerable number of the societies. We shall be glad to receive any corrections to the list as published, for the sake of our own records.

Air Brake Association. Secy., F. M. Nellis, 111 Broadway, New York; Pres., L. M. Carlton, 5803 Erie St., Chicago, Ill. 688 Members.

American Association for the Advancement of Science. Secy., L. O. Howard, Cosmos Club, Washington, D. C.; Pres., W. H. Welch, Johns Hopkins University, Baltimore, Md. Over 4,000 Members.

American Association of Inventors and Manufacturers. Secy., Arthur Stewart, Washington Loan & Trust Bldg., Washington, D. C.

American Boiler Manufacturers' Association. Secy., J. D. Farasey, Forest St. and Erie Railway, Cleveland, Ohio; Pres., R. Munroe, Jr., Pittsburg, Pa. 114 Members.

American Ceramic Society. Secy., Edward Orton, Jr., Columbus, Ohio; Pres., W. D. Richardson, Columbus, Ohio. 187 Members.

American Chemical Society. Secy., W. A. Noyes, Bureau of Standards, Washington, D. C.; Pres., W. F. Hillebrand, U. S. Geological Survey, Washington, D. C. 2,819 Members.

American Civic Association. Secy., C. R. Woodruff, North American Building, Philadelphia, Pa.; Pres., J. H. McFarland, Harrisburg, Pa.

American Economic Association. Secy., F. A. Fetter, Ithaca, N. Y.; Pres., F. W. Taussig, Harvard University, Cambridge, Mass. 870 Members.

American Electrochemical Society. Secy., S. S. Sadtler, 39 South Tenth St., Philadelphia, Pa.; Pres., W. D. Bancroft, Cornell University, Ithaca, N. Y. 683 Members.

American Forestry Association. Secy., H. M. Suter, 510 Twelfth St., N. W., Washington, D. C.; Pres., Hon. James Wilson, Washington, D. C. 4,600 Members.

American Foundrymen's Association. Secy., Dr. Richard Moldenke, P. O. Box 432, New York.; Pres., Thos. D. West, Sharpsville, Pa. 288 Members.

American Gas Light Association. Secy., George G. Ramsdell, 530 Broadway, New York.; Pres., Charles F. Prichard, Lynn, Mass. 919 Members.

American Institute of Architects. Secy., Glenn Brown, The Octagon, Washington, D. C.; Pres., Frank Miles Day, Philadelphia, Pa.

American Institute of Electrical Engineers. Secy., R. W. Pope, 95 Liberty St., New York; Pres., Dr. Schuyler S. Wheeler, Ampere, N. J. 3,594 Members.

American Institute of Mining Engineers. Secy., R. W. Raymond, 99 John St., New York.; Pres., Jas. Gayley, 71 Broadway, New York City. 3,886 Members.

American Mathematical Society. Secy., F. N. Cole, 501 West 116th St., New York; Pres., W. F. Osgood, Harvard University, Cambridge, Mass. 504 Members.

American Mining Congress. Secy., J. F. Callbreath, Jr., Chamber of Commerce Building, Denver, Colo.; Pres., J. H. Richards, Boise, Idaho.

American Mosquito Extermination Society. Secy., Henry Clay Weeks, Bayside, L. I., New York; Pres., W. J. Matheson, 184 Front St., New York.

American Paper and Pulp Association. Secy., Adam K. Luke, 309 Broadway, New York.; Pres., W. N. Caldwell.

American Public Health Association. Secy., Dr. C. O. Probst, Columbus, Ohio; Pres., F. C. Robinson, Brunswick, Me. 589 Members.

American Public Works Association (Contractors). Secy., W. H. Flint, Chattanooga, Tenn.; Pres., J. A. Omberg, Jr., Memphis, Tenn. 87 Members.

American Railway Association. Secy., W. F. Allen, 24 Park Place, New York.; Pres., W. C. Brown, New York. (Membership by Railway Companies; 313 Members, representing 226,830 miles of railway.)

American Railway Engineering and Maintenance of Way Association. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.; Pres., H. G. Kelley, Minneapolis, Minn.

American Railway Master Mechanics Association. Secy., J. W. Taylor, 390 Old Colony Building, Chicago, Ill.; Pres., H. F. Ball, Cleveland, Ohio. 750 Members.

American Roadmakers' Association. Secy., W. S. Crandall, Postal Telegraph Building, New York.; Pres., H. S. Earle.

American Roentgen Ray Society. Secy., Dr. George C. Johnston, 514 Bijou Building, Pittsburg, Pa.; Pres., Dr. Henry Hulst, 88 Fountain St., Grand Rapids, Mich.

American Society of Civil Engineers. Secy., Charles Warrent Hunt, 220 West 57th St., New York; Pres., F. P. Stearns, 1 Ashburton Place, Boston, Mass. 3,569 Members.

American Society of Heating and Ventilating Engineers. Secy., W. M. Mackay, P. O. Box 1818, New York; Pres., John Gormly, 1433 Columbus Ave., Philadelphia, Pa. 243 Members.

American Society of Inspectors of Plumbing and Sanitary Engineers. Secy., James S. Cassedy, Woburn, Mass.; Pres., Henry B. Davis, Washington, D. C.

American Society of Mechanical Engineers. Secy., Prof. F. R. Hutton, 12 West 31st St., New York; Pres., F. W. Taylor, Philadelphia, Pa. 2,929 Members.

American Society of Municipal Improvements. Secy., G. W. Tillson, Municipal Building, Brooklyn, N. Y.; Pres., Chas. Carroll Brown, Indianapolis, Ind.

American Society of Naval Engineers. Secy., Theo. C. Fenton, Lieutenant-Commander U. S. Navy, Washington, D. C.; Pres., A. B. Canaga, Commander U. S. Navy, Washington, D. C. 612 Members.

American Society of Railroad Superintendents. Secy., C. A. Hammond, Mt. Vernon, N. Y.; Pres., W. L. Derr, Erie R. R., Elmira, N. Y.

American Society of Refrigerating Engineers. Secy., W. H. Ross, Suite 806, 258 Broadway, New York.; Pres., W. Everett Parsons, 12 Bridge St., New York. 119 Members.

American Society for Testing Materials. Secy., Prof. Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.; Pres., Dr. Chas. B. Dudley, Altoona, Pa. 808 Members.

RIBBED ARCH BRIDGE AT NOWY SACZ, GALICIA.

American Street and Interurban Railway Association. Secy., B. V. Swenson, 60 Wall St., New York; Pres., W. C. Ely, Buffalo, N. Y. 200 Members.

American Street and Interurban Railway Accountants' Association. Secy., E. M. White, 2019 Thirteenth Ave., South, Birmingham, Ala.; Pres., W. B. Brockway, Yonkers, N. Y. 152 Members.

American Street and Interurban Railway Engineering Association. Secy., S. W. Mower, 12 Woodward Ave., Detroit, Mich.; Pres., H. H. Adams, Baltimore, Md. 192 Members.

American Water-Works Association. Secy., J. M. Diven, 14 George St., Charleston, S. C.; Pres., B. C. Adkins, 312 City Hall, St. Louis, Mo. 495 Members.

Appalachian Engineering Association. Secy., H. M. Payne, Lock Drawer P, Williamson, W. Va. 45 Members.

Architectural League of America. Secy., W. E. Stone, care National Arts Club, 37 West 34th St., New York; Pres., F. S. Lamb.

Architectural League of New York. Secy., F. E. Wallis, 215 West 57th St., New York.; Pres., Arnold W. Brunner, 33 Union Sq. West, New York. 425 Members.

Association of American Portland Cement Manufacturers. Asst. Secy., C. E. E. Bottomly, 1232 Land Title Building, Philadelphia, Pa.; Pres., John B. Lober, 1230 Land Title Building, Philadelphia, Pa. 47 Members.

Association of American Railway Accounting Officers. Secy., C. G. Phillips, 79 Dearborn St., Chicago, Ill.; Pres., J. O. Clifford, C. & N. W. Railway, Chicago, Ill. 487 Members.

Association of Boards of Public Service of Ohio. Secy., C. H. Frank, Columbus, Ohio.; Pres., Charles Krone, Hamilton, Ohio.

Association of Edison Illuminating Companies. Secy., W. S. Barstow, 56 Pine St., New York.

Association of Engineering Societies. Secy., F. K. Brooks, 31 Milk St., Boston, Mass. (11 Local engineers' societies and clubs, devoted chiefly to civil engineering.)

Association of Fire and Police Telegraph Superintendents and Municipal Electricians. Secy., Henry Y. Blackwell, Jr., Brooklyn, N. Y.

Association of Ontario Land Surveyors. Secy., Killaly Gamble, 94 Huntley St., Toronto, Ont.; Pres., James W. Tyrrell, 42 James St., N., Hamilton, Ont. 284 Members.

Association of Railway Superintendents of Bridges and Buildings. Secy., S. F. Patterson, Concord, N. H.; J. B. Sheldon, Providence, R. I. 313 Members.

Association of Railway Telegraph Superintendents. Secy., P. W. Drew, Wisconsin Central Railway, Milwaukee, Wis.; Pres., E. E. Torrey, Jackson, Tenn. 133 Members.

Association of Transportation and Car Accounting Officers. Secy., G. P. Conard, 24 Park Place, New York; Pres., H. L. Hunter, Minneapolis, Minn.

Boston Society of Civil Engineers. Secy., S. E. Tinkham, 715 Tremont Temple, Boston, Mass.; Pres., John W. Ellis, 20 Market Sq., Providence, R. I. 601 Members.

Brooklyn Engineers' Club. Secy., Joseph Strachan, 197 Montague St., Brooklyn, N. Y.; Pres., Willard S. Tuttle, 83 N. 10th St., Brooklyn. 280 Members.

Buffalo Railroad Association. Secy., F. A. Kister, Buffalo, N. Y.; Pres., G. W. Bartlett, Dunkirk, N. Y.

California Miners' Association. Secy., ——; Pres., A. A. Tregidgo, Vallejo, Cal.

California Street Railway Association. Secy., J. E. Morris, Oakland, Cal.

Canadian Electrical Association. Secy., C. H. Mortimer, Electrical News, Toronto, Canada.; Pres., A. A. Wright, Renfrew, Ont.

Canadian Mining Institute. Secy., H. Mortimer-Lamb, Room 4, Windsor Hotel, Montreal, P. Q.; Pres., Geo. R. Smith, Thetford Mines, P. Q.

Canadian Railway Club. Secy., James Powell, Grand Trunk Ry., Montreal, P. Q.; Pres., S. King, Can. Pac. Ry., Montreal.

Canadian Road Masters' Association. Secy., J. Drinkwater, Canadian Pacific Railway, Winchester, Ont.; Pres., A. McAuley, Toronto Junction, Ont.

Canadian Society of Civil Engineers. Secy., C. H. McLeod, 877 Dorchester St., Montreal, P. Q.; Pres., H. D. Lumsden, Ottawa, Ont. 1,291 Members.

Central Association of Railroad Officers. Secy., O. G. Fetter, 11 Carew Building, Cincinnati, Ohio.; Pres., George Hannauer, St. Louis, Mo.

Central Electric Railway Association. Treas., W. F. Mulholland, Indianapolis, Ind.; Pres. E. C. Spring.

Central Railway Club. Secy., H. D. Vought, 62 Liberty St., New York; Pres., C. H. Hogan, N. Y. C. & H. R. R. R., Depew, N. Y. 386 Members.

Central States Water-Works Association. Secy., W. A. Veach, Newark, Ohio; Pres., W. H. Ferguson.

Chicago Association of General Superintendents of Railways. Secy., J. D. Besler, Supt. C., B. & Q. R. R., Chicago, Ill.; Pres., J. W. Higgins.

Chicago Railroad Association. Secy., W. J. Cannon, Chicago, Ill.; Pres. Geo. W. Vaux.

Chief Joint Car Inspectors' and Car Foremen's Association. Secy., D. T. Taylor, St. Louis, Mo.; Pres., H. Boutet, Cincinnati, Ohio.

Civil Engineers' Club of Cleveland. Secy., J. C. Beardsley, 1200 Schofield Building, Cleveland, Ohio.; Pres., B. L. Green, Osborn Building, Cleveland, Ohio. 248 Members.

Civil Engineers' Society of St. Paul. Secy., C. L. Annan, Department of Public Works, St. Paul, Minn.; Pres., Oscar Claussen, German-American Bank Building, St. Paul. 67 Members.

Colorado Electric Light, Power and Railway Association. Secy., George B. Tripp, Colorado Springs, Colo.

Concrete Association of New York. Secy., T. G. Barr, care Vulcanite Portland Cement Co., Fiftiron Building, New York; Pres., R. F. Tucker.

Concrete Block Machine Manufacturers' Association of the United States. Secy., S. L. Wiltse; Pres., J. F. Angel.

Connecticut Electric Lighting Association. Secy., A. F. Hunie, New Haven, Conn.; Pres., James English, New Haven, Conn.

Connecticut Society of Civil Engineers. Secy., J. F. Jackson, New Haven, Conn.; Pres., Albert B. Hill, New Haven, Conn.

Detroit Engineering Society. Secy., C. W. Hubbell, 232 Jefferson Ave., Detroit, Mich.; Pres., T. H. Hinchman.

The Electric Club. Secy., C. E. Downton, Box 911, Pittsburg, Pa.; Pres., F. D. Newbury.

Engine Builders' Association of the United States. Secy., J. I. Lyle, 39 Cortlandt St., New York.

Engineering Association of the South. Secy., H. M. Jones, Room 2, Berry Block, Nashville, Tenn.; Pres., J. W. Kendrick, Birmingham, Ala. 216 Members.

Engineering Society of the Lehigh Valley. Secy., L. O. Danse, Lehigh University, South Bethlehem, Pa.

Engineers' Club of New York. Secy., C. M. Wales, 374 Fifth Ave., New York.; Pres., W. H. Fletcher, Hoboken, N. J. 1,243 Members.

Engineers' Club of Baltimore. Secy., Joseph W. Shirley, City Hall Annex, Baltimore, Md.; Pres., Charles E. Phelps, Jr., Baltimore. 71 Members.

Engineers' Club of Central Pennsylvania. Secy., W. G. Miller, Second and Walnut Sts., Harrisburg, Pa.; Pres., J. V. W. Reynders, Steelton, Pa.

Engineers' Club of Chicago. Secy., Lewis M. Ellison, 1800 Fisher Building, Chicago, Ill.

Engineers' Club of Cincinnati. Secy., C. H. Meeds, P. O. Box 333, Cincinnati, Ohio.; Pres., James A. Lilly, Pleasant Ridge, Ohio. 94 Members.

Engineers' Club of Columbus. Secy., F. R. Brosius, 12½ N. High St., Columbus, Ohio; Pres., W. K. Lanman.

Engineers' Club of Minneapolis. Secy., J. B. Gilman, 1225 Seventh St., S. E., Minneapolis, Minn.; Pres., H. B. Avery.

Engineers' Club of Philadelphia. Secy., W. L. Webb, 1122 Girard St., Philadelphia, Pa.; Pres., Thos. C. McBride, 724 Arch St., Philadelphia. 528 Members.

Engineers' Club of St. Louis. Secy., R. H. Fernald, 3817 Olive St., St. Louis, Mo.; Pres., W. A. Layman, 2017 Locust St., St. Louis. 236 Members.

Engineers' Club of Toronto. Secy., Willis Chipman, 96 King St., West, Toronto, Canada; Pres., F. L. Somerville, Union Station, Toronto. 145 Members.

Engineers' Society of Southwest Missouri. Secy., H. E. Elrod, Joplin, Mo.; Pres., George P. Maury, Joplin. 50 Members.

Engineers' Society of Western New York. Secy., T. J. Rogers, The Library Building, Buffalo, N. Y.; Pres., Louis H. Knapp. 56 Members.

Engineers' Society of Western Pennsylvania. Secy., F. V. McMullin, 410 Penn Ave., Pittsburg, Pa.; Pres., Julian Kennedy, 1217 Bessemer Bldg., Pittsburg, Pa. 921 Members.

Engineers' and Architects' Club of Louisville, Ky. Secy., Pierce Butler, 303 Norton Building, Louisville, Ky.; Pres., Henry Vogt., 211 East Broadway, Louisville. 76 Members.

Franklin Institute. Secy., W. H. Wahl, 15 South Seventh St., Philadelphia, Pa.; Pres., John Birkinbine, Odd Fellows' Temple, Philadelphia. 1,491 Members.

Geological Society of America. Secy., H. L. Fairchild, University of Rochester, Rochester, N. Y.; Pres., Israel C. Russell, Ann Arbor, Mich. 271 Members.

Henry Electrical Society. Secy., D. R. Lovejoy, 111 West 28th St., New York.

Honolulu Engineering Association. Secy., E. G. Keen; Pres., A Gartley.

Illinois Society of Engineers and Surveyors. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.; Pres., Dabney H. Maury, Peoria, Ill. 155 Members.

Illinois State Electrical Association. Secy., H. E. Chubbuck, La Salle, Ill.

Illuminating Engineering Society. Secy., Geo. H. Guy, 109 Liberty St., New York; Pres., L. B. Marks, 220 Broadway, New York. 192 Members.

Independent Telephone Association of the United States. Secy., W. J. Vesey, Fort Wayne, Ind.

Independent Telephone Association of Wisconsin. Secy., W. F. Goodrich, La Crosse, Wis.; Pres., R. Valentine, Janesville, Wis.

Indiana Electric Railway Association. Secy., P. H. White, Indianapolis, Ind.

Indiana Engineering Society. Secy., Charles C. Brown, Commercial Club Bldg., Indianapolis, Ind.; Pres., R. P. Woods, Traction Terminal Bldg., Indianapolis. 125 Members.

Indianapolis Engineering Club. Secy., W. E. Bucher; Pres., C. C. Brown.

Indianapolis Technical Club. Secy., Charles Brossman, Jr., No. 28 Hotel Denison, Indianapolis, Ind.; Pres., Chas. Carroll Brown, Indianapolis.

International Acetylene Association. Secy., Lucius S. Bigelow, 265 Broadway, New York; Pres., Giles W. Mead, Chicago, Ill.

International Association of Car Accountants and Car Service Officers. Secy., L. G. Corcoran, Penn. R. R., Buffalo, N. Y.; Pres., G. H. Waldo, Cincinnati, Ohio.

International Association of Fire Engineers. Secy., James McFall, Roanoke, Va.; Pres., John Stagg, Paterson, N. J. 579 Members.

International Association of Municipal Electricians. Secy., F. P. Foster, Corning, N. Y.; Pres., Jerry Murphy, Cleveland, Ohio. 74 Members.

International Society of State and Municipal Building Commissioners and Inspectors. Secy., F. W. Fitzpatrick, 4200 14th St., Washington, D. C.; Pres., Jas. Mulcahy, Boston, Mass. 54 Members.

Interstate Independent Telephone Association. Secy., E. M. Coleman, Louisville, Ky. Pres., C. E. Hull.

Iowa Electrical Association. Secy., George S. Carson, Iowa City, Iowa.

Iowa Engineering Society. Secy., C. L. Bryden, Iowa City, Iowa; Pres., Seth Dean, Glenwood, Iowa. 104 Members.

Iowa Railway Club. Secy., W. B. Harrison, Union Station, Des Moines, Iowa; Pres., W. B. Foster, Des Moines. 227 Members.

Iowa Street and Interurban Railway Association. Secy., L. D. Mathes, Dubuque, Iowa; Pres., Geo. B. Hippee, Des Moines, Iowa. 33 Members.

Kansas Gas, Water and Electric Association. Secy., J. D. Nicholson, Newton, Kans.; Pres., W. E. Sweezy, Junction City, Kans. 84 Members.

Lake Superior Mining Institute. Secy., A. J. Yungbluth, Ishpeming, Mich.; Pres., G. H. Abeel, Hurley, Wis.

League of American Municipalities. Secy., John MacVicar, Des Moines, Iowa; Pres., R. G. Rhett, Charleston, S. C.

League of Michigan Municipalities. Secy., Prof. John A. Fairlie, Ann Arbor, Mich.; Pres., Edwin F. Sweet, Grand Rapids, Mich. 35 Members (Cities and Villages).

Louisiana Engineering Society. Secy., Marcel Garsaud, Room 604, Tulane-Newcomb Building, New Orleans, La.; Pres., W. H. Hoffmann, New Orleans, La. 73 Members.

Maine Street Railway Association. Secy., E. A. Newman, 471 Congress St., Portland, Me.

Massachusetts Electric Lighting Association. Secy., E. W. Burdett, 84 State St., Boston, Mass.; Pres., Chas. L. Edgar, Boston. 29 Members (Companies).

Massachusetts Street Railway Association. Secy., Charles S. Clark, 70 Kilby St., Boston, Mass.; Pres. E. C. Foster.

Master Car Builders' Association. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.; Pres., Joseph Buker, Chicago. 650 Members, representing 1,900,000 freight cars.

Master Car and Locomotive Painters' Association. Secy., A. P. Dane, B. & M. R. R., Boston, Mass.; Pres., H. M. Butts, Albany, N. Y. 227 Members.

Master Steam Boiler Makers' Association. Secy., George M. Clark, 1377 Maplewood Ave., Chicago, Ill.; Pres., W. M. Wilson, 7155 South Chicago Ave., Chicago, Ill. 227 Members.

Memphis Engineering Society. Secy., C. C. Pashby, 127 Madison St., Memphis, Tenn.

Michigan Engineering Society. Secy., F. Hodgman, Climax, Mich.; Pres., Prof. H. K. Vedder, Agricultural College, Mich.

Michigan Gas Association. Secy. Alonzo P. Ewing, 230 Woodward Ave., Detroit, Mich.; Pres., W. H. Barthold, Saginaw, Mich. 178 Members.

Michigan Street Railway Association. Secy., B. S. Hanchett, Jr., Grand Rapids, Mich.

Minneapolis Engineers' Club. Secy., E. P. Birch.

Minnesota Surveyors' and Engineers' Society. Secy., Arthur E. Morgan, St. Cloud, Minn.; Pres., J. E. Hill, St. Cloud.

Montana Society of Engineers. Secy., Clinton H. Moore, Room 16, Leyson Block, Butte, Mont.; Pres., Bertram H. Dunshee, Butte.

Municipal Engineers of the City of New York. Secy., Wisner Martin, Cambridge Court, West 49th St., New York; Pres., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y. 367 Members.

National Association of Cement Users. Secy., Charles C. Brown, Commercial Club Building, Indianapolis, Ind.; Pres., Richard L. Humphrey, Harrison Bldg., Philadelphia, Pa.

National Association of Manufacturers. Secy., Marshall Cushing, 170 Broadway, New York; Pres., David M. Parry, Indianapolis, Ind. 3,000 Members.

National Association of Manufacturers of Sand-Lime Products. Secy., H. O. Duerr, Diamond Stone-Brick Co., Wilmington, Del.; Pres., W. K. Squier, Syracuse, N. Y. 87 Members.

National Association of Marine Engineers of Canada. Secy., Neil J. Morison, St. John, N. B.; Pres., F. S. Henning, Toronto, Ont.

National Association of Railway Commissioners. Secy., Edward A. Moseley, Washington, D. C.; Pres., W. G. Smith, Sturgis, S. Dak. 137 Members.

National Brick Manufacturers' Association. Secy., T. A. Randall, Indianapolis, Ind.; Pres., John R. Copeland, Birmingham, Ala. 655 Members.

National Electric Light Association. Secy., W. C. L. Eglin, 136 Liberty St., New York.; Pres., Wm. H. Blood, Jr., Seattle, Wash. 636 Companies; 287 Individuals.

National Fire Protection Association. Secy., W. H. Merrill, Jr., 382 Ohio St., Chicago, Ill.; Pres., Chas. A. Hexamer, 135 South Fourth St., Philadelphia, Pa. 680 Members.

National Geographic Society. Secy., O. P. Howard, Hubbard Memorial Hall, Washington, D. C.; Pres., W. L. Moore.

National Irrigation Association. Executive Chairman, George H. Maxwell, 812 Whitehall Building, New York; Pres., Thos. F. Walsh, Washington, D. C.

National Machine Tool Builders' Association. Secy., P. E. Montanus; Pres., W. Lodge.

National Municipal League. Secy., C. R. Woodruff, 705 North American Building, Philadelphia, Pa.; Pres., Chas. J. Bonaparte, Baltimore, Md.

National Sanitary Association. Secy., Thos. E. Veal, Atlanta, Ga.

Natural Gas Association of America. Secy., J. H. Dunkel, Citizens' Light, Heat & Power Co., Lawrence, Kans.; Pres., K. M. Mitchell, St. Joseph, Mo.

Nebraska Irrigation Association. Secy., Joseph Oberfelder, Sidney, Nebr.

New England Association of Gas Engineers. Secy., N. W. Gifford, East Boston, Mass.; Pres., Capt. Wm. McGregor. About 150 Members.

New England Association of Railroad Superintendents. Secy., E. A. Smith, B. & M. Railroad, Boston, Mass.; Pres., I. N. Marshall, Taunton, Mass.

New England Cotton Manufacturers' Association. Secy., C. J. H. Woodbury, Boston, Mass.

New England Railroad Club. Secy., E. L. Janes, 185 Sumner St., Boston, Mass.; Pres., C. F. Allen, Mass. Inst. of Technology, Boston.

New England Street Railway Club. Secy., John J. Lane, 12 Pearl St., Boston, Mass.; Pres., Paul Winsor, Boston.

New England Water-Works Association. Secy., Willard Kent, Narragansett Pier, R. I.; Pres., Wm. T. Sedgwick, Boston, Mass. 667 Members.

New Jersey Sanitary Association. Secy., James Exton, M. D., Arlington, N. J.; Pres., H. M. Herbert, Bound Brook, N. J. 142 Members.

New York Electrical Society. Secy., George H. Guy, 114 Liberty St., New York; Pres., Wm. S. Barstow, 56 Pine St., New York. 647 Members.

New York Railroad Club. Secy., Harry D. Vought, 62 Liberty St., New York; Pres., H. H. Vreeland, New York. 1,000 Members.

New York State Electrical Contractors' Association. Secy., Wells Dygert, Buffalo, N. Y.

Northwest Railway Club. Secy., T. W. Flannagan, M., St. P. & S. S. M. Railway, Minneapolis, Minn.; Pres., L. E. Wolgemuth, St. Paul, Minn. 346 Members.

Northwestern Cement Products Association. Secy., George A. Hughes, 1401 Hennepin Ave., Minneapolis, Minn.; Pres., C. A. P. Turner, Phoenix Bldg., Minneapolis.

Northwestern Electrical Association. Secy., B. C. Adams, Madison, Wis.; Pres., Harold Almert, Chicago, Ill. 148 Members.

Ohio Electric Light Association. Secy., D. L. Gaskill, Greenville, Ohio; Pres., F. E. Valentine, Piqua, Ohio.

Ohio Engineering Society. Secy., E. G. Bradbury, 85 North High St., Columbus, Ohio; Pres., G. A. McKay, Xenia, Ohio.

Ohio Gas Light Association. Secy., T. C. Jones, Delaware, Ohio; Pres., Donald McDonald, Louisville, Ky. 739 Members.

Ohio Society of Mechanical, Electrical and Steam Engineers. Secy., F. W. Ballard, 104 Canal St., Cleveland, Ohio; Pres., Wm. T. Magruder, Columbus, Ohio. 199 Members.

Ohio Street Railway Association. Secy., Charles Currie, Akron, Ohio.

Pacific Coast Gas Association. Secy., John A. Britton, San Francisco, Cal.; Pres., John Martin, San Francisco, Cal. 264 Members.

Pacific Coast Railway Club. Secy., C. C. Borton, Southern Pacific Co., West Oakland, Cal.; Pres., W. A. Doble, San Francisco, Cal. 313 Members.

Pacific Northwest Society of Engineers. Secy., A. H. Dimock, 617 Pioneer Building, Seattle, Wash.; Pres., James D. Blackwell, 95 Yesler Way, Seattle, Wash. 134 Members.

Pennsylvania Street Railway Association. Secy., Charles H. Smith, Lebanon, Pa.

Pike's Peak Polytechnic Society. Secy., E. A. Sawyer, Colorado Springs, Colo.

Pittsburg Foundrymen's Association. Secy., F. H. Zimmers, 410 Market St., Pittsburg, Pa.

Polytechnic Society of Utah. Secy., M. S. Hanauer.

Provincial Mining Association. Secy., A. L. Belyea, Victoria, B. C.; Pres., J. Keen, Kaslo, B. C.

Railway Club of Pittsburg. Secy., John D. Conway, P. & L. E. Railroad, Pittsburg, Pa.; Pres., F. H. Stark, Coraopolis, Pa. 632 Members.

Railway Signal Association. Secy., H. S. Balliet, 335 Madison Ave., Room 1137, New York; Pres., C. H. Morrison, Jersey City, N. J. 569 Members.

Railway Superintendents' Association of Memphis. Secy., R. A. Macdonald, Memphis, Tenn.; Pres., W. J. Hills, Paducah, Ky.

Railway Water Supply Association. Secy., F. W. Hayden, Glencoe, Minn.; Chairman, M. D. Colt, 157 North 17th St., Minneapolis, Minn.

Richmond Railroad Club. Secy., F. O. Robinson, C. & O. Ry., Richmond, Va.; Pres., W. H. Owens, Manchester, Va.

Road and Track Supply Association. Secy., J. N. Reynolds, 1660 Monadnock Block, Chicago, Ill.; Pres., W. E. Clark, Board of Trade Bldg., Montreal, P. Q.

Roadmasters' and Maintenance of Way Association of America. Secy., C. E. Jones, Beardstown, Ill.; Pres., C. Buhrer, Sandusky, Ohio. 384 Members.

Rochester Engineering Society. Secy., J. F. Skinner, Reynolds Library, Rochester, N. Y.; Pres., J. H. Grant.

Rocky Mountain Railway Club. Secy., S. N. Mitchell, 1141 Evans St., Denver, Colo.; Pres., J. H. Manning, U. P. R. R., Cheyenne, Wyo.

St. Louis Railway Club. Secy., E. A. Chenery, Mo. Pac. Building, St. Louis, Mo.; Pres., John J. Baulch, St. Louis. 1,025 Members.

St Paul Society of Civil Engineers. Secy., A. L. Annan; Pres., A. R. Starkey.

Scranton Engineers' Club. Secy. H. M. Warren, 302 Board of Trade Building, Scranton, Pa.; Pres., A. E. Lister, Scranton. 253 Members.

Society of Chemical Industry. Secy. New York Section, H. Schweitzer, 40 Stone St., New York; Pres. N. Y. Section, Dr. R. W. Moore, Orange, N. J. 1,396 Members in U. S.

Society of Engineers of Eastern New York. Secy., A. E. Cluett, P. O. Box 666, Troy, N. Y.; Pres., James F. McElroy, Albany, N. Y. 191 Members.

Society of Gas Lighting. Secy., George G. Ramsdell, 530 Broadway, New York; Pres., Col. Frederick S. Benson, Brooklyn, N. Y. 40 Members.

Society of Naval Architects and Marine Engineers. Secy., W. J. Baxter, 12 West 31st St., New York; Pres., Francis T. Bowles, Quincy, Mass. 808 Members.

Society for the Promotion of Engineering Education. Secy., M. S. Ketchum, Boulder, Colo.; Pres., C. L. Crandall, Ithaca, N. Y. 396 Members.

Southern and Southwestern Railway Club. Secy., W. A. Love, P. O. Box 755, Atlanta, Ga.; Pres., O. G. Cheatham, Fernandina, Fla.

Southwestern Gas, Electric and Street Railway Association. Secy., T. H. Stuart, Waco, Tex.; Pres., H. F. MacGregor. About 81 Members.

Street Railway Association of the State of New York. Secy., C. B. Fairchild, Jr., Room 1002, 114 Liberty St., New York; Pres., R. E. Danforth, Rochester, N. Y.

Technical Club of Omaha. Secy., J. Harry Lawrie, Omaha, Neb.

Technical Society of New York. Secy., Wm. Mueser, 35 Nassau St., New York.

Technical Society of the Pacific Coast. Secy., Otto von Geldern, San Francisco, Cal.; Pres., George W. Dickie, San Francisco. 167 Members.

Technological Society of Kansas City. Secy., Burton Lowther, 804 Locust St., Kansas City, Mo.; Pres., J. Robert Moechel, Kansas City. 80 Members.

Texas Association of Civil Engineers. Secy., S. A. Miller, San Antonio, Tex.; Pres., J. W. Maxcy, Houston, Tex. 55 Members.

Toledo Society of Engineers. Secy., J. C. Oliphant, 2111 Ashland Ave., Toledo, Ohio; Pres., E. O. Fallis, Toledo. 72 Members.

Train Dispatchers' Association of America. Secy., J. F. Mackie, 7042 Stewart Ave., Chicago, Ill.; Pres., F. X. Meyers, Marshall, Tex. 993 Members.

Traveling Engineers' Association. Secy., W. O. Thompson, 167 West Fifth St., Oswego, N. Y.; Pres., A. L. Beardsley, Ft. Madison, Iowa. 586 Members.

Underwriters' National Electric Association. Secy., C. M. Goddard, 55 Kilby St., Boston, Mass.; Pres., H. C. Eddy, Chicago, Ill.

United States Naval Institute. Secy., Prof. Philip R. Alger, Annapolis, Md.; Pres., Rear-Admiral C. F. Goodrich, U. S. N. 933 Members.

Vermont Electrical Association. Secy., C. C. Wells, Middlebury, Vt.; Pres., E. E. Gage, St. Johnsbury, Vt. 24 Members.

Washington Society of Engineers. Secy., Louis D. Bliss, 219 G St., N. W., Washington, D. C.; Pres., Admiral Chas. W. Rea, Navy Dept., Washington. 352 Members.

Western Association of Technical Chemists and Metallurgists. Secy., H. C. Parmelee, P. O. Box 1421, Denver, Colo.; Pres., F. W. Traphagen.

Western Foundrymen's Association. Secy., B. M. Gardner, 1522 Monadnock Block, Chicago, Ill.

Western Gas Association. Secy., James W. Dunbar, New Albany, Ind.; Pres., Paul Doty, St. Paul, Minn. 596 Members.

Western Railroad Association. Secy., E. P. Amory, 1330 Marquette Bldg., Chicago, Ill.; Pres., Lloyd W. Bowers, Chicago.

Western Railway Club. Secy., J. W. Taylor, 390 Old Colony Building, Chicago, Ill.; Pres., J. A. Carney, Burlington, Iowa. 1,108 Members.

Western Society of Engineers. Secy., J. H. Warder, Monadnock Block, Chicago, Ill.; Pres., B. J. Arnold, Marquette Bldg., Chicago. 824 Members.

West Virginia Society of Civil Engineers and Architects. Secy., Wm. Steenberger, Point Pleasant, W. Va.

Wilkinsburg (Pa.) Electric Club. Secy., C. E. Downton.; Pres., E. M. Olin.

Wisconsin Engineers' Society. Secy., F. J. Harriman, Appleton, Wis.

Wisconsin Gas Association. Secy., Henry H. Hyde, Racine, Wis.; Pres., John Corscot. About 69 Members.

Wood Preservers' Association. Secy., C. W. Berry, U. P. R. R., Laramie, Wyo.; Pres., C. B. Lowry, Shirley, Ind. 48 Members.

A UNIVERSAL DICTIONARY OF MECHANICAL DRAWING.*

By George H. Follows.†

Part VIII.: The Record Strip.

120. A mechanical drawing—by which is meant the "illustrated specification," as defined in Part VII., paragraph 95—is not complete until it has been titled and numbered.

121. In drafting rooms the world over it has long been customary to allow the title to include, in addition to a description of the contents of the drawing, the name and address of the firm; and also to have it carry the drawing number, the scale of the work, the signatures of those who shared in making the drawing, and the date of completion.

122. A generation ago draftsmen were permitted to elaborate these titles by the use of ornamental lettering and other more or less artistic embellishment; in fact, the title was often a very conspicuous feature, being executed according to the individual taste of the draftsman, who would appear to have had more spare time than he knew what to do with. Such a title, made about thirty-five years ago, is shown in Fig. 32. It occupied the lower right hand part

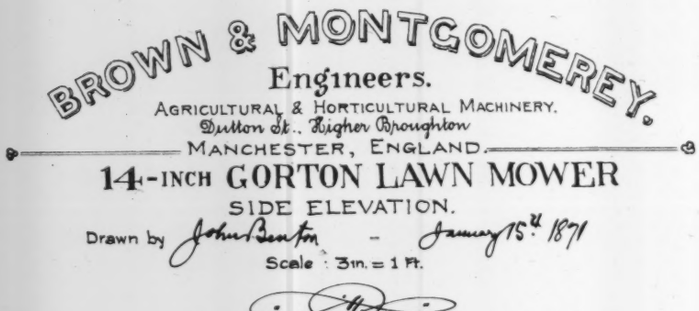


FIG. 32. REPRODUCTION OF TITLE OF AN OLD DRAWING.

of the drawing, and covered fully one-eighth of the entire sheet.

123. The form of title used to-day by a modern firm of machine tool builders is shown in Fig. 33. In this, neatness and uniformity are assured by having those parts that are common to all titles press-printed in the lower right hand corner of the sheet, ready for the draftsman to fill in. This title has an official appearance entirely lacking in Fig. 32; it also carries records of changes and other data of value.

124. These may be taken as typical examples of titles ancient and modern. At first sight they appear to offer a great contrast; but it is almost at once evident that they differ in appearance and design rather than in general character, although the one does carry certain record data not found in the other. A serious fault common to both—and common to titles in general today—is that they are designed to occupy the lower right hand corner of the drawing, thus rendering a valuable part of the sheet permanently unavailable for drawing on, whether convenient or not; and another fault—also common to titles in general—is that they are collections of dissimilar items.

125. There is no valid reason why the name and address of a firm, the number and scale of a drawing and the place where it is filed, the dated signatures of several draftsmen, sundry order numbers, data regarding changes and pieces affected, and a description of the contents of a drawing, should be crowded together into a kind of potpourri design and christened "title." It is an attempt to mix things that should be separated—probably the result of conservatism, that unconscious tendency in drafting rooms to stand by old traditions.

126. Fig. 34 shows what can be done by systematically distributing these items as "record data" over a narrow strip extending across the entire foot of the drawing. By this arrangement a clear rectangle is always available for drawing on, which is as it should be; and the record strip affords ample space for all necessary records. The exact nature of these records—in other words, the contents of the record strip—cannot be defined in such a way as to fully meet the varied requirements of all drafting rooms, but the following will serve as an example of what the contents may be, to be modified according to the conditions existing in any particular drafting room:

(1) Firm name and address.
(2) Title—descriptive of the contents of the drawing.
(3) Drawing number.
(4) Scale.
(5) Dated signatures of those who took part in the making of the drawing.
(6) Dated O. K. signature of the person, generally the chief draftsman, who is officially and finally responsible for the drawing.

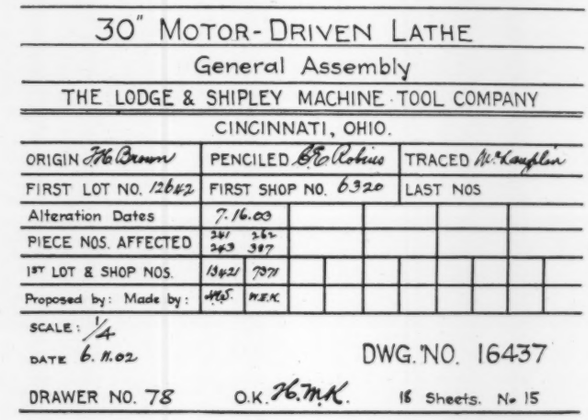


FIG. 33. REPRODUCTION OF A MODERN DRAWING TITLE.

(7) Sub-numbers.
(8) First order number, or its equivalent, in connection with which the drawing, as defined by each sub-number, is used.
(9) Records of changes for which new sub-numbers were given.

127. Of these items the first six do not call for special comment; the last three do, because they directly influence the permanent and uninterrupted efficiency of every drawing *after it has once been changed from the condition in which it was originally used*; and there are comparatively few drawings made that do not require changing at one time or another.

128. One of the most prolific sources of trouble in the modern drafting room and shop is this changing of drawings; especially when the change affects a piece that has to be supplied for repairing a machine built prior to the making of the change. In such a case, if there is any doubt as to what the drawing specified before the change was made, annoying troubles are almost sure to follow.

129. There are many ways in which drafting rooms take care of such changes, as by the use of special record prints made prior to the change and filed away for future reference, but it would be out of place to enter into any consideration of them here. Whatever system is used, the drawing itself—the tracing—should carry some record of every change, even though it be no more than the date of the change, with a list of the pieces affected and the order number in connection with which the changed drawing was first used. A very simple way of doing this is illustrated in Fig. 34. The original drawing—that is the drawing *as first used in the shop*—is called Sub No. 1. Then when a change is made that in any way affects work to be done in the shop or the interchangeability of any piece, the drawing is given Sub No. 2, redated and signed, and under Sub No. 1 a record is made of what the drawing was *as* Sub No. 1; that is before the change was made necessitating the use of Sub No. 2. When this system is used it must be understood by all concerned that references to drawing numbers always mean the *latest* Sub No., unless otherwise specified. Other suggestions regarding the use of the record strip will be found in Fig. 34.

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†The Park View, East Liberty, Pittsburg, Pa.

SOME ORIGINAL LETTERS OF GEORGE AND ROBERT STEPHENSON.

A collection of original letters written by the two Stephensons, whose names are among the most famous in the annals of English engineering, has recently come into the possession of Mr. Edwin H. Frost, of the business staff of this journal. Through his courtesy, we are able to select the following letters for publication. The first of them, it will be seen, was written in the very early days of the railway era. The famous Liverpool & Manchester trials, in which Stephenson's "Rocket" was victorious, occurred in 1829.

It is interesting to note the evidence which the letters present of the feverish activity in railway construction which prevailed in England (and in the United States as well at the same time). The Stephensons, it is clear, were active and pushing business men as well as engineers; and with their great prestige and the abundant opportunities which the new system of transportation opened, they were able to rapidly amass fortunes. John Dixon, to whom these letters were addressed, appears to have been a long-time personal friend engaged also in the work of railway construction, but as a professional engineer on a salary.

Knowing something of the violent opposition with which the early railway promoters were met, it is easy to conjecture that "Old Joseph Pease," referred to in the postscript to the first letter, may very likely have been some prominent pillar of the opposition forces whose keen business sense had compelled him finally to invest in the very schemes which he had virulently opposed.

[No date, but received Oct. 7, 1835, and written from Alton Grange, Ashby.]

Dear Dixon,

Were you in want of a situation I should be most happy to have you with me. I have been obliged to reject several applications made to me from the promoters of several new Railways on account of not having time to devote to them. Your salary it appears (I know) is not equal to that of some who have not been in the profession so long as yourself and it is of course for your own consideration whether to continue in your present employment at £600 a year or to launch out, at some degree of risk, for £1,000, or perhaps more. I think it is quite certain, now, that a Line of Railway will be procured & continued from the London & Nowtn. (Northwestern) to Newcastle-on-Tyne—& that very shortly. We have a most excellent Line from Derby to Leeds passing thro' Belper, Chesterfield—betwixt Rotherham and Sheffield—thence by Barnsley, Wakefield & on to Leeds. The Ground is extremely favorable, no part of it will exceed 16 ft. in a mile—from Leeds to the north of Engd. you know that the Ground is good by way of York and thence to Darlington—so that it is very clear, now, that

the Grand Trunk thro' Engd. must be on this Route. We shall take in Huddersfield, Halifax and Bradford by cheap Branches. I set off tonight for London to go over the Brighton and also the Blackwall Line. I shall be back in a week—let me hear from you, how you are going on.

Yours very faithfully,
(Signed) GEO. STEPHENSON.

You will be astonished to hear from me that old Joseph Pease has taken 200 Shares in the Brighton Line. He has also taken 100 Shares in the London & Birm. Line.

Mrs. Stephenson desires her kind love to yourself and Sister Jane and expected to have seen you both long since, but hope to see you soon.

Respecting your own affairs let this Letter be in confidence. Vignoles is busy with laying out a Line from Rugby to Derby—this will be another Southampton Job for the Manchester people. What sagacity they have in their speculations!

(Addressed:)
Mr. John Dixon
Engineer
Railway Station, Manchester.

Tapton House, Jany 11, 1845.

My dear Sir,

I duly recd. yours of the second of January. I shall see Robert shortly & will show him your letter about the Engines. if they cannot sell the Engines to other people they must trust you till you can pay.

I wish I had an opportunity of seeing you a little oftener. you are always getting alarmed about little things. Keep up your spirits you will be all right in the course of this summer you have no occasion to fret about a situation as long as I am in the Land of the Living. I have just tendered for another large Coal Field in this District & I also intend to open out some extensive Lead Mines. When you cannot get a situation on Railways I shall be sure to have something for you. I am making experiments with the Whitby Iron Stone, if it turns out favorable I shall make extensive works in that District. We are going to Parliament to have the duty of Coals taken off entering the Port at Whitby,—that is what may be required for the Manufacture of Iron. I have had 50 Tons of the Stone sent into Staffordshire to be tried by itself there.

You will see in the papers that I have put a little life into the Burnly, Blackburn & Preston people. I think we shall now take up the connecting Link from the Darlington Railway to the Durham and Sunderland Junction and thence to the Brandling Junction. This will complete the thoroughfare from London to Newcastle. It is in such a state that we can go to Parliament this year for the bill, I think the bill is sure to be got. You will recollect as soon as the Country is Ripe I have my 10 more Lines to come out. Mrs. Stephenson & Miss Brown joins me in kind regards to Mrs. & Miss Jane Dixon.

I am, dear Sir, Yours truly,
(Signed) GEO. STEPHENSON.

John Dixon Esq.

Put this letter by to be looked at Two years hence if you and I live. Whoever believed me three years ago when I stated that I should regulate the price of Coals nearly throughout the whole of the Towns of the South of England. Before the frost set in I was selling Coals in London, Reading, in Berkshire, Oxford, Banbury, and other places on the Oxford Canal. I am now just going to commence a sale at Nottingham which is within 7 or 8 miles of the Nottingham Coal Field & my colly. is 36 miles from Nottingham. I shall lower the price of Coals 2 shillings per ton at that Place.

---

24 Great George St N W
9 August 49

Dear Dixon

When the present apparatus at the Stownes Gill was erected, the construction of a Bridge or an Embankment occupied my attention and very careful consideration.

I am quite satisfied that nobody can calculate with any chance of approaching to accuracy the cost or time requisite to form an Embankt. The bottom is certainly bad, for borings were made. These borings I dare say are in the possession of Mr. Thomas Harrison and I have no doubt he will give you any information he has on the subject.

No one who has had any experience in Embankments and Bridge building can maintain that the former is cheaper than the latter at such a height as 170 feet. under ordinary circumstances the cost is about equal at 70 or 80 ft., every increase above this gives arching the advantage.

I am aware the section of the Stownes Gill is peculiar, and renders the application of this line of argument not strictly applicable, but certainly not to such an extent as to affect the truth of the conclusion.

In constructing a bridge I should be inclined to dispense with piling by introducing inverted arches into a foundation wall laid entirely across the gill, carrying a solid rubble wall a considerable depth below the inverts into the ground. By this arrangement you would distribute the weight of the superstructure over the entire area of the bottom. This would I believe be both cheaper and safer than piling where a treacherous material exists as a foundation.

Hoping these remarks are such as you want, I am yours faithfully

(Signed) ROB STEPHENSON.

P. S. I do not think wood desirable in such a situation—the height is too great, and the chance of fire as well as decay are serious contingencies. The only process that seems to resist decay is that of Creosote but its combustibility is a fatal objection in Bridge Building.

Tapton house Novr 20: 1846.

My Dear Sir

I have received yours of the 17th inst. When my eye caught your hand writing I thought the Sea had been breaking in upon you; however I am happy to find I was mistaken.

If I am right informed the sea has done more damage to Brunel's line than the whole cost of your Whitehaven & Maryport line; this report however may have been over-stated. There has not been very much damage done to Holyhead; the storm got hold of some unfinished walls as it did you.

With respect to the extras made out by the Contractors on your line I think the best thing for you to do will be to say that you will explain the whole matter to me or my Son. I see very little harm in making out a detail

UNIVERSAL DRAWING DICTIONARY

A B

4378

EXPLANATORY.

In this illustration the rectangle ABCD represents the drawing trimmed to size, and EFCD is the Record Strip completely filled in as an example.

The depth ED of the strip, which for very small drawings may be about 1", may conveniently be the same for all drawings of the same size.

The strip should be divided into rectangular spaces suited to the contents, which in this example may be specified as follows:-

Dwg. No.	FIRM NAME AND ADDRESS		Scale	Dwg. No.
Draftsman's Signature Dated	SUB No. First Order No. O.K. Signature, dated	SUB No. First Order No. O.K. Signature, dated.	TITLE	
Tracer's Signature Dated	Statement of what the drawing was under this Sub No.; that is BEFORE the change was made.			
Checker's Signature Dated				

The drawing number, which should be in bold and clear figures, appears not only at each end of the strip, but also at the extreme upper left hand corner A of the sheet, where it is inverted, so that when a drawing happens to be piled up with others wrong way around its number may always be read right way up in the same relative position on the sheet — the lower right hand corner.

Those parts of the strip that are common to all the drawings of the same firm may with advantage be press printed on the tracing. This helps to uniformity.

E F

4378	THE AMERICAN MACHINE CO., Pittsburgh, Pa., U.S.A.		Scale ½ 4378
Draftsman: J.B. Brown 3-2-05	1 1st Order No. 7142 O.K. Tr/Md. 3-5-05	2 1st Order No. 8639 O.K. Tr/Md. 2-6-06	48" TRIPLE-GEARED LATHE. MOTOR DRIVEN VARIABLE SPEED MECHANISM. DETAILS.
Tracer: John Williams 3-4-05	Clutch Ring was C.I. Sleeve was 3" long. Piece 326 was ⅞" dia.		
Checker: W.H. Smith 3-4-05			

D C

FIG. 34: THE RECORD STRIP.

—if it is fair for the Contractor to have the extras I should fear no man in stating it; but I think the best way will be to let me go through them with you.

I am surprised about your Cockermouth line; I think along with you that Lord Lonsdale is hard to deal with: you should have given notice to go to Parliament to take what land you liked and to settle it by Jury: this however might have cost more money than his Lordship's claims would amount to. I think you may be right, it is better to give the price at once.

I have desired John to seek out a copy of my report; you recollect I did send you a copy at the time I sent it to Lord Lonsdale.

You are aware that I have given up the Whitehaven and Furness railway into Robert's hands—I want now almost to retire from business; and I think, although you are not near my age you ought to be doing the same; but more about this when I see you.

I feel greatly obliged to Jane for staying with me until I find some person to take charge of my house; she does very well for the parties we have—it is only the large parties that I am afraid she would be frightened with.

I am sorry to hear that Mrs. Dixon is unwell when she gets better I shall be happy to see you and her here. I have just had a letter from your Brother Robert who arrived in England the other day. My kind regards to Mrs. Dixon &

I am Dear Sir
Yours truly
(Signed) GEO. STEPHENSON.

A NEW FINE GRINDING MACHINE FOR CEMENT MILLS.

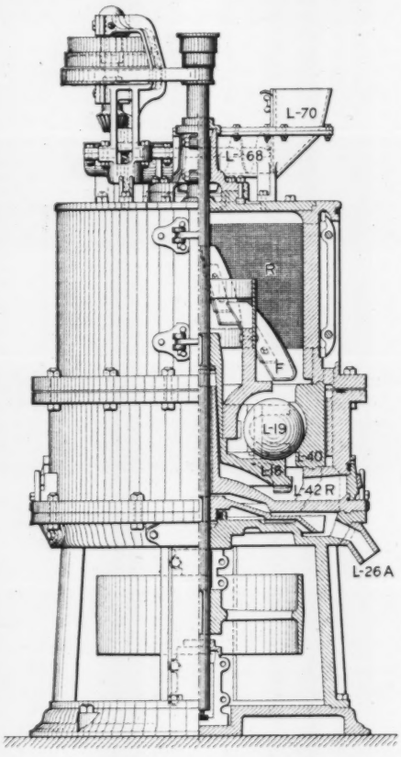
By Richard K. Meade.*

The grinding proposition of a modern Portland cement mill is one of the toughest mechanical problems which now confronts the mechanical engineer. At a plant producing 1,000 barrels a day, over 500 tons of material must be ground to an almost impalpable powder every 24 hours. Of this quantity 300 tons represent the raw material which must be reduced from pieces of stone as large as a man can handle to such a degree of fineness that from 95 to 98% of the product will pass a 100-mesh sieve. The other 200 tons represent the slag-like clinker which must be pulverized so fine that at least 92% of it will pass this sieve. The coal necessary to furnish the motive power for the machinery employed to grind this quantity of material and the labor and material required to keep this machinery in operating order constitute the most important items in the cost of Portland cement manufacture. Consequently the modern wide-awake manufacturer is continually striving to secure greater efficiency out of the grinding machinery which he now has installed or is looking about for more efficient crushers and pulverizers to take the place of the ones he now has. The means now at hand for reducing material to a size passing a ½-in. ring screen are fairly efficient, consequently the search has largely been confined to the securing of a pulverizer to reduce the material from the size delivered by rolls and crushers to that necessary for the final product for the kilns or the market.

In view of the importance of the cement manufacturer's being posted on the best methods of pulverizing, I have undertaken below to describe a new mill which is giving unusually good results wherever tried and which promises to become an important factor in the grinding of cement, its raw materials and the coal for their burning. This mill is called the Fuller-Lehigh Pulverizer Mill and is manufactured by the Lehigh Car, Wheel & Axle Works, Catasaqua, Pa.

This grinder as shown in the illustration consists of a horizontal ring or die, L 40, against which revolve four balls L 19. The balls are propelled by means of a pusher L 18 A, upon which the balls also rest. The die, pusher and balls are made of chilled Swedish iron, and the latter weigh 112 lbs. each and are 9¼ ins. in diameter. They revolve at a speed of about 210 revolutions per minute and hence press against the die with enormous (centrifugal) force. The material to be ground is fed into the hopper L 70 and from this into the mill by means of the screw conveyor L 68. The material entering the center of the mill falls down into the pan of the mill, situated below the die, and is thrown up from this, in between the rapidly revolving balls and the stationary die, by means of plow L 42 R. The material is pulverized by the rolling of the ball against the die, the pressure of each ball against the latter being over 1,600 lbs., the grinding action being similar to that of a mortar and pestle. The fully pulverized material is sucked upwards by the fans, F, and blown through the screen R, falling down between this screen and the outer casing and being discharged from the mill at L 26 A. The coarse particles being too large and too heavy to be carried upward and through the screens by the fans fall back into the trough to be again thrown up between the die and the balls, etc.

The plows and pushers are all attached to a central shaft which is driven from below by means of a pulley. This shaft extends through the top of the mill and actuates the feeding device. The feed to the mill and consequently the fineness of the product may be controlled in two ways—either by a slide on the hopper or by means of the stepped pulley, connected to the screw conveyor by gearing. The mill is provided with two screens—one, the inner of 1-in. mesh and made of very heavy wire to protect the fine outer one. This outer screen on mills designed for pulverizing coal and rock is a 35 mesh screen and is made of No. 29 wire, while that on mills for cement clinker is 40 mesh and is made of No. 31 wire. The outer screen can be replaced with only a few minutes delay. Indeed the whole mill can be quickly dismantled. The mill is mounted on a heavy iron base, is entirely encased and is practically dustless when running. There is an opening, covered by a plate, in the top of the mill and a light may be lowered through this into the mill to examine the screens, balls, pushers, etc., at any time the mill is not running.



A New Fine Grinding Machine for Cement Mills.
Lehigh Car Wheel & Axle Works, Catasauqua, Pa., Builders.

The fineness of the product delivered by the mill can be regulated by increasing or diminishing the feed to the mill. The size of the fine screen surrounding the mill also controls the fineness to some extent. It is possible with this mill to secure a product of almost any degree of fineness.

As will be seen by referring to the above description, the only parts of the mill which can wear are the balls, pushers, the die and the screen. As the die wears it conforms to the contour of the balls, and the closer contact between the two results in a greater output of the mill. The central shaft is not subject to sudden and constant jars, and hence will not crystallize and break. The parts subject to wear, of which the balls get most can be quickly replaced. The screens on clinker last on an average three weeks and on the cement rock limestone mixture of the Lehigh Valley last at least two months. The balls and pushers wear from a minimum of one month on very hard clinker to two months on raw material and three to four months on coal. Practically the only parts of the mill which have to be replaced are the balls, pushers and screens. The pushers are reversible and hence when worn on one side they can be turned around. The tire or die will last over two years. The actual cost of keeping one of these mills on clinker in repairs at one of the plants of this section amounted to $45 per month on an average, while on raw materials the repairs only cost $16.72 per month average.

The mill requires about 35-40 HP. to operate, and requires small floor space, hence shorter main shafts are needed than would be the case with ball and tube mills. The mills take up less space than any other pulverizer mill of similar capacity and require but a small amount of foundation. They may be placed in a row and driven from one line shaft, doing away with the loss of power in the counter shafts necessary to drive any considerable number of tube mills. They can be quickly set up. Cement plants having insufficient grinding capacity will find this an excellent mill to help out their other grinders, because the small amount of floor space which it requires will permit of its being "tucked away" in some corner where other grinding machinery could not be put, from lack of room.

The mill is also much less expensive than any other form of pulverizer. This is, however, but a small part of the saving effected by the installation of this mill. The small floor space which it requires, allows the construction of smaller building and foundations and shorter shafts and conveyors. There is also a saving in power by their use, which economizes in engine and boiler installation.

The material should be prepared for this mill by means of a set of rolls just as would be done for a Griffin mill; or Kominuters, provided with coarse screens, may be used for this purpose. The Fuller-Lehigh Pulverizer Mill has been used in the Lehigh Valley for grinding raw material, Portland cement clinker and coal. At the plant of the Bath Portland Cement Co. the writer recently made a test of one of these mills grinding raw material (cement rock and limestone) with the result that the mill ground 4¼ tons per hour to a fineness of 95.9% through a No. 100 sieve and 90.9% through a No. 200 sieve.

At another time the mill ground 3.9 tons per hour to a fineness of 96.4% through a No. 100 sieve and 91.9% through a No. 200 sieve. The assistant superintendent told me that he considered these tests as representative ones, and that he had frequently tested these mills under unfavorable circumstances such as very coarse or damp feed and had never found them doing less than 3½ tons per hour to a fineness of at least 93% through a No. 100 sieve.

In the above test of the Fuller mill, the feed to the mill was the product of a set of rolls and consisted of material a large part of which would not pass a ½-in. ring screen.

The importance of fine grinding of the raw material is now so well understood that it is hardly necessary here to more than emphasize the fact that the finer the raw material is ground the better. Fine grinding is not only necessary in order to produce a sound cement which will stand the boiling test, but it also makes the raw material easier to clinker and consequently increases the capacity of the kilns and decreases the coal consumption. As showing the necessity of fine grinding of the raw material the writer may mention the fact that in one instance which came under his observation it was found impossible to make the cement stand the boiling test

*Chemical Engineer, Nazareth, Pa.

when the raw materials were ground to a fineness of only 90% through a No. 100 sieve, while no difficulty at all was experienced in doing this if the fineness of the raw material was increased to 95% through this sieve, the composition remaining the same.

A remarkable fact about the product of this mill is the relatively large amount of fine material passing a No. 200 sieve in comparison with that passing a No. 100 sieve. This has a very important bearing on its use as a cement pulverizer. The value of cement depends upon the amount of impalpable powder or flour it contains, and, generally speaking, the greater the percentage of 200 mesh product for a given fineness through the No. 100 sieve the greater will be the quantity of flour in the cement. The gritty particles of cement have practically no value, and any mill which produces fineness without flour is not suited to grinding cement.

As a pulverizer for cement a Fuller mill on a recent test run at the plant of the Phoenix Cement Co. ground 3,459 lbs., or 9.1 bbls per hour, to a fineness of 92.2% through the No. 100 sieve and 76.9% through the No. 200 sieve. The clinker for this test was especially hard, well burned clinker, and was prepared for the Fuller-Lehigh mill by ball mills. Wishing to confirm his theory that the product of this mill contained an unusually large amount of "flour," the writer had briquettes made of some of the cement ground during this test-run, with the result that his views were entirely borne out, as the following unusualy high breaks will show:

	7 days.	28 days.
Briquettes, 1 part cement 3 parts standard sand.	416	438
	438	418
	392	429
	385	435
	402	403
Average	406.6	424.6

At another plant the mill is grinding 12 bbls. per hour to a fineness of 95.3% through a No. 100 sieve and 81.6% through a No. 200 sieve. This mill is working on the tailings from an air separator. At a test-run recently made to show how fine a product could be obtained with a Fuller-Lehigh pulverizer it was found possible to grind cement as fine as 99% through a No. 100 sieve and 95% through a No. 200 sieve. At this fineness the mill had a capacity of 4¾ bbls. per hour. This test shows how valuable the mill would be to "pull up" the fineness of mills already installed, but which will not give a product of the necessary fineness to fill standard specifications, or for burning a sound cement without seriously cutting down their efficiency and increasing the wear and tear upon them. Probably no other mill could be economically run to produce such extremely fine cement. At the end of the four days' run at this fineness, the mill showed no unusual signs of wear or strain.

The Fuller mill has been used continually upon coal at the Alpha Portland Cement Co. They consider it efficient and economical. Its being dustless also adds greatly to its value as a coal pulverizer, reducing the danger of fire and explosions. At this plant three mills are used to furnish coal for four 60-ft. and six 80-ft. kilns. This mill grinds on a minimum 2¼ tons of coal per hour to a fineness of 95-98% through a No. 100 sieve. The importance of grinding the coal for the rotary kilns very fine is not as well understood as it should be. Coarsely ground coal does not ignite promptly, and consequently is wasted by incomplete combustion in the upper part of the kiln to carbon monoxide.

The writer has found as high as 3% of this constituent in the stack gases of kilns fired with coarsely ground coal, while under normal conditions, with finely ground coal, the amount of carbon monoxide present is seldom over 1%, and may often be as low as 0.2%.

As a final example of what the Lehigh-Fuller mill is doing, one of the new mills of the Lehigh district some six weeks ago put in one of these mills upon trail, grinding cement rock and limestone mixture. The manager of this plant told me he had repeatedly tested the output of this mill and had never found it less than 3½ tons per hour, of a fineness of at least 95% through the No. 100 sieve. As the result of his six weeks' trial of this mill he will throw out all of the machinery now installed in the "raw mill" and the coal mill to do the final pulverizing and replace it by Fuller-Lehigh pulverizer mills, using Kominuters to prepare for these.

BOX CAR WITH HATCHES FOR LOADING AND UNLOADING THROUGH THE ROOF: TEHUANTEPEC NATIONAL RAILWAY, MEXICO.

The Tehuantepec National Railway, of Mexico, is an interoceanic line built especially for the handling of ocean freight, and has its docks and piers equipped with special machinery for transferring freight rapidly between ships and cars. The rolling stock equipment includes a number of box cars which are provided with large openings or hatches in the roof to enable the dock cranes to handle loads directly in and out of the cars. The dock warehouses have hatches in the roofs for the same purpose. The construction for the cars is shown in the accompanying cuts, Figs. 1 and 2. The hatchway in the middle of the roof is 10 ft. long and the full width of the car. The ends are formed by pressed steel carlines of channel section, having a greater height than the ordinary carlines, while each side is formed by two angles with a wooden stick between them. The upper angle on each side forms a runway for the steel rollers carrying the door or hatch, which slides lengthwise of the roof. This hatch is of 3/16-in. steel plates, with stiffening angles on the upper side.

The cars have steel underframes and upper framing. There are two plate-girder center sills of the fish-belly pattern, while the side and end sills are steel channels; pressed steel struts are fitted between the sills, as well as 4-in. channels to carry longitudinal 4 × 4-in. floor beams. The bolsters are of box section, having plate-girder sides and large top and bottom cover plates. For the upper framing, the side posts, diagonals and roof plates are of angles, while the end posts are light I-beams. The carlines have triangular web plates, with a stiffening angle on each edge, making a Z-section. Large connection plates are used throughout the steel framing, as shown. The outside sheathing is of wood, and there is an inside sheathing to the height of the belt rail. The roof has a plank sheathing, covered with corrugated galvanized iron. These cars are being built by the American Car & Foundry Co., of St. Louis, Mo., and their principal dimensions are given below:

Length over end sills	37 ft. 11 ins.
Length inside	36 ft. 0 ins.
Width over side sills	9 ft. 3⅜ ins.
Width inside	8 ft. 6 ins.
Height inside (to car lines)	8 ft. 0 ins.
Height, rail to top of brake shaft	14 ft. 4¾ ins.
Side doors	6 ft. 0 ins. × 7 ft. 5 ins.
Roof hatch	10 ft. 0 ins. × 8 ft. 6 ins.
Wheels, diameter	2 ft. 9 ins.
Wheelbase, truck	5 ft. 2 ins.
Wheelbase, total	31 ft. 6 ins.
Carrying capacity	60,000 lbs.

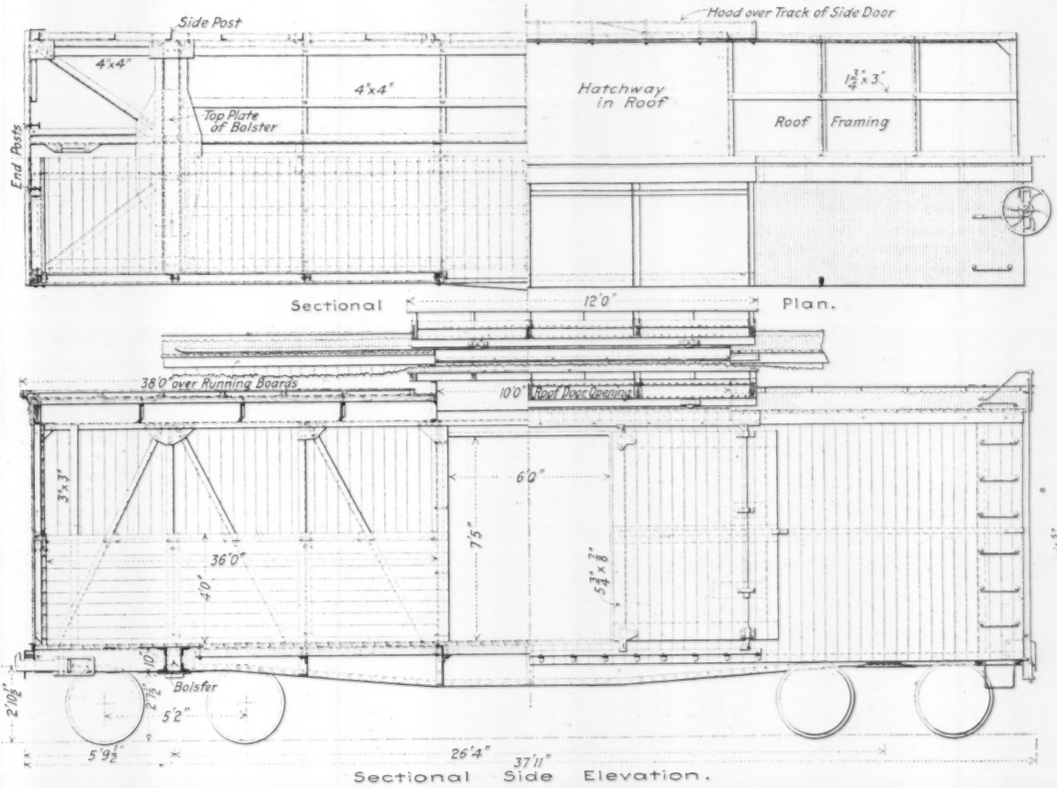


FIG. 1. BOX CAR WITH ROOF HATCH: TEHUANTEPEC RAILWAY (MEXICO).
American Car & Foundry Co., St. Louis, Mo., Builders.

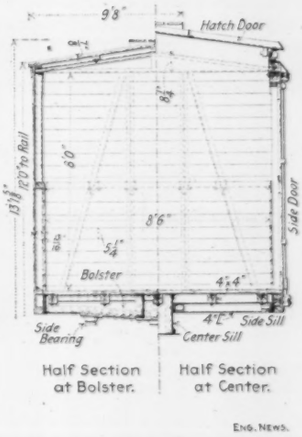


Fig. 2. Cross Section of Box Car with Roof Hatch.

SWITCHBACKS ON THE CROWN KING EXTENSION OF THE SANTA FE, PRESCOTT & PHOENIX RY.

The extension of the Santa Fe, Prescott & Phoenix Ry. (Santa Fe System) from Meyer to Crown King, Ariz., is an interesting example of a railway built on the switchback principle in order to reduce cost in heavy mountainous country. For plans and particulars of this line we are indebted to Mr. W. A. Drake, M. Am. Soc. C. E., General Superintendent and Chief Engineer of the railway, at Prescott, Ariz. The road was projected by Mr. F. M. Murphy, of Prescott, as an extension of the Prescott & Eastern Ry. (now acquired by the line above-mentioned) to Crown King to develop a mining district in the Bradshaw Range, and in view of the fact that the traffic would be limited and must be developed by the railway, it was essential that the line should be built at a low cost. The general plan of the line is shown in Fig. 1. Before commencing the steepest part of the ascent it was necessary to cross the deep and narrow gorge of Turkey Creek, the only alternative being a long detour which would have involved a costly and almost impracticable location across a district having numerous deep canyons. The elevation at the crossing of Turkey Creek is 3,370 ft., and that of Crown King is 5,806 ft. (above sea level); the distance is only nine miles, but any line between them must traverse a very rough section of the mountains.

The first plan was for an ordinary line, and it was found possible to overcome the 2,436 ft. difference in elevation by a location having 4% grades and sharp curves, but involving several tunnels and the crossing of many deep canyons. The high cost made such a line impracticable, especially in view of the small amount of traffic. The problem then was to find a line that could be built within reasonable limits of cost, and Mr. Drake proposed and directed a switchback line, which was located by Mr. J. A. Jaeger, Assistant Engineer. A maximum grade of 3½% equalized, with 16° curves, was adopted, and by a careful selection of places on which to locate the back-up lines, a cheap and practicable route was located. The difficulties due to snow, etc., were duly considered in adopting the location. It was considered also that the loss of time in working over the switchbacks would be very small, while objections on the score of running trains backward were of little practical moment, as the speed would necessarily be slow in either direction. It was, therefore, decided that a material saving in cost of construction would be effected with very little additional expense in operation, and the line was built on the switchback location. It was completed in 1904.

The total length of the line is 28 miles and the ascent of 2,436 ft. between Turkey Creek and Crown King is accomplished in a distance of 17 miles. The total distance between the first and last switchbacks is nine miles, with a difference in elevation of 1,328 ft. There are ten switchbacks with five back-up sections of line. These sections are from 1,500 to 4,000 ft. in length and have slightly easier grades and curves than the go-ahead sections, in order to give the trains a little advantage when backing up. The tails of the back-up sections are at present about 300 ft. long and are continued on a rising grade of 2% beyond the switchstands, the maximum grade approaching the switchstands being 3½%. The frogs are No. 6½ and No. 9. Fig. 2 shows a profile of part of the switchback line, with plans of two of the switchbacks. The track is laid with 65-lb. rails, and on the 16° curves the gage is widened ¾-in.

The engines used are of the consolidation (2-8-0) type, with a rigid wheelbase of 13 ft. 6 ins., and the weight of engine and train is about 226 tons. The average speed over the switchback section of the line is about 15 miles per hour. Mr. Drake states that the train crew has become so handy at the work, that a brakeman drops off the last car as it passes the switch, and the engine is backing before a passenger can hardly realize that the train has been stopped.

THE GASOLINE CAR FOR INTERURBAN SERVICE.*

By F. W. Hild.†

In view of the present widespread interest in steam railroad circles in the self power-contained car as a means of meeting the increasingly severe competition of the electric roads, it may not be amiss to consider this type of car from the view point of the electric railway engineer.

That the large roads have keenly felt the electric railway competition has long been known and it is now particularly evidenced by the various methods under consideration for meeting it. Thus the Union Pacific has built at its Omaha shops a straight gasoline car, wherein the power output of a gasoline engine is mechanically transmitted to the car wheels. The Chicago, Burlington & Quincy some months ago built at its Aurora shops, and

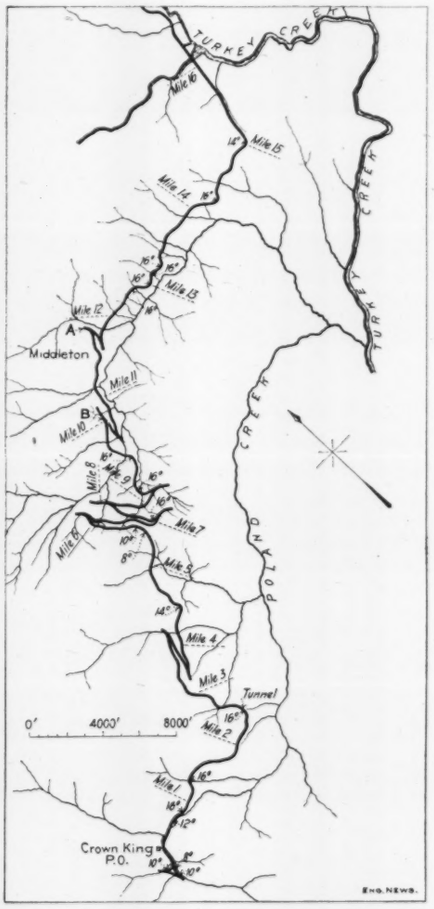


Fig. 1. Map of Switchback Extension of the Santa Fe, Prescott & Phoenix Ry. to Crown King, Ariz.

W. A. Drake, M. Am. Soc. C. E., General Superintendent and Chief Engineer.

for a short time experimentally operated, a gasoline electric car, wherein the power output of the gasoline engine was transmitted electrically to the wheels. The Delaware & Hudson has placed in operation a gasoline electric car built by the General Electric Co. The Lake Shore is also trying such a type of car. The Ohio River & Columbus Ry., according to the technical press, is experimenting with a steam propelled car, which is to be a modern edition of the old time steam dummy. The press very recently described the Strang electric railway car, a gasoline electric car which ran with its own power from Philadelphia, where it was built, to Kansas City, where it is to go into service on an interurban road in that vicinity.

The writer has seen experimental outfits utilizing the automobile principle of carrying the motive power on the truck frame. In one case it was a high pressure superheated steam engine with direct chain transmission and with flash boiler, kerosene or gasoline pan burner, radiating condenser, etc., all very much the same as the equipment of the well-known "White" steam automobile. In another case it was a four-cylinder gasoline engine, with friction disk transmission, etc., similar to automobile equipment.

The independent motor car idea had its inception abroad and much more work has been done in this direction in France, Germany and Great Britain than in this country. The most conspicuous application of the idea is the steam motor cars of the Great Western Railway of Great Britain. This railway has in use a number of modernized steam dummy cars using coal as fuel for steam generation. The preference on the continent seems to be for the internal combustion engine and several experimental gasoline engine cars are being tried. The Wurtemberg Street Railway is one of the most aggressive of foreign roads in trying the independent motor car. This railway has experimented with electric storage battery cars, with steam motor cars of the Serpollet type and gasoline cars of the Daimler motor type. It is interesting to note that the Wurtemberg Street Railway put an independent gasoline motor car into service in December, 1893, something over 12 years ago.

There can be no doubt that most of the several types of self power-contained cars will find useful fields of application and will become valuable auxiliaries to the standard forms of rail transportation; but also, in the judgment of the writer, there should be no doubt that these fields of application will be relatively restricted and do not include such as are now served by the standard electric system.

The factors which have made electric traction so brilliantly successful in city, urban and interurban service are many and varied, but those which enter into a discussion involving a consideration of other types of motor cars are:

(a) Reliability and simplicity.
(b) High schedule speeds and high train frequency.
(c) Cleanly and noiseless operation.
(d) Low cost of operation and of maintenance.

On the other hand, the self powered cars enjoy two advantages which are the sole reasons for the present interest in this type of car. They are:

(e) Absence of external power transmission circuits.
(f) Lesser initial investments.

It is the purpose of this paper to briefly investigate and compare these several factors.

DESCRIPTIVE.

The straight electric system has been in use some 17 to 18 years, and its essential features of power-station, substation, transmission line, overhead or third-rail conductor, track return circuit, trolley and car equipments, are well understood by all railway men. The several types of independent power-contained cars have been described at different times in the technical press.

Apparently the greatest difficulty encountered by the designers of the gasoline cars is the transmission of power from the engine to the driving wheel. This is not surprising in view of the fact that the internal combustion engine is essentially a constant speed motor, and that railway work demands wide ranges of variable speeds. At the present time the favorite means appears to be the use of electricity, indicating that the difficulties of direct mechanical transmission and variable speed operation are so great as to warrant the rather roundabout transmission involved by the addition of generator, with or without batteries, and the standard railway type motors and control. Indeed it is claimed by the promoters that the efficiency of the gasoline electric outfits compares very favorably with any type of mechanical transmission and moreover, has the greater advantages of large variations of speed, flexible driving, ease of control, and lesser wear and tear. The acceleration and changes of speed are smooth, and without the jar or shock which is ever present with any mechanical change-speed gear. This situation suggests to electrical engineers the early discussions of series vs. shunt motors for railway work. The designers of the gasoline-electric cars, while fully agreed as to the method of power application, nevertheless differ among themselves on the important question of power supply—thus some insist that a storage battery is an indispensable adjunct, for the reason that gasoline engines have low efficiencies at fractional loads and furthermore have practically no overload margin; the battery, therefore, is needed to take care of the recurring inevitable overloads. Others, however, prefer to use a much larger generating unit, largely because of the saving in weight and space, and the avoidance of acids and fumes.

GENERAL COMPARISON.

RELIABILITY.—It probably needs no argument to show that the straight electric car considered alone is far less complicated and hence far more reliable than any other form of motor car. The straight electric has the minimum of moving parts, all of which (excepting the brake mechanism, which are common to all cars) are non-reciprocating, while all other types of self propelled cars have reciprocating mechanisms, which include a great number of moving parts, more or less complicated in adjustment. The greater simplicity and reliability of the standard electric car is perfectly obvious in the fact that, aside from the conductor or fare collector, but one attendant, the motorman, is necessary for the car operation, whereas, every type of independent railway motor car, so far as the writer knows, requires an additional

*From a paper read before the Iowa Street and Interurban Railway Association.

†Chief Engineer, Southwestern Wisconsin Ry., Dubuque, Iowa.

skilled mechanic to look after the portable power plant. Of course efforts are and will be made to render the equipment so thoroughly automatic as to permit the dispensation of this skilled mechanic. Far be it from the writer's wish to infer that American inventive ingenuity may not accomplish this, but a few healthy doubts as to its early attainment are permissible when one remembers the automobile enthusiast who stated that he owned a car for three years, of which he spent one year on it and the other two under it. The annoyances which may attend the use of a private vehicle may be tolerated by the owner, but such annoyances would be prohibitive in a public utility like a transportation system, therefore the need of minimizing interruptions and delays will undoubtedly compel the retention of the extra attendant.

But the question of reliability of the straight electric goes beyond the car itself and involves a consideration of power generation and transmission. Power generating machinery, both steam and electric, has been brought to a very high order of development, and in the hands of thoroughly competent operators, the probability of interruption of power service through failure of this machinery is extremely remote, particularly if the plant be provided with a judicious, yet reasonable, reserve. There are plants in this country which have operated for years without failing to deliver power, and it has come to be understood that the engineer who fails to "keep the busses hot" must have an exceptionally good excuse in order to retain his job.

The power transmission to the cars is by conductors running parallel to the track, generally carried overhead, sometimes close to the track, as on third-rail roads, and sometimes under the track as on slotted conduit roads. Where converter substations are in use for changing the generated electric power to different voltages or kind of current, "power transmission" includes high tension conductors which are carried in the form of multiple conductor cables underground, or as separate conductors overhead on poles.

In the earlier days the power transmission did not receive the attention of designing and construction engineers so much as the power machinery, and in consequence there were many troubles with the earlier transmission circuits. These earlier experiences served to give the power transmission system a reputation for weakness which was never fully deserved and which now no longer obtains. The modern transmission circuit whether for alternating or direct currents is of sturdy construction, mechanically strong and reliable, so that the percentage of failures due to all causes except the elements is no greater and usually less than experienced with other parts of the roadway.

The elements, however, introduce difficulties into power transmission of the overhead variety, which have at times been the cause of provoking interruption to service, but at the extreme such interruptions are nothing worse than brief temporary stoppage of the cars and are not accompanied by the fatal disasters consequent to the broken track rail, the misplaced switch, the defective or storm weakened bridge or the faulty signal. The heavy substantial construction of modern transmission and overhead conductor systems enables them to withstand the ravages of storms very successfully, more so than the present telegraph, telephone and signal transmission systems and it is not unusual to hear of electric roads maintaining service during storms that tie up the steam roads. The greatest source of disturbance to power transmission systems is lightning. Considerable progress has been made in recent years through careful study and experiment by leading engineers, in the development of adequate means for protecting electrical apparatus against lightning. As a result, protective devices are now available which limit interruptions to service to such a point that the transmission circuit given proper and reasonable attention is fully as reliable in every respect as any other part of the railway system.

SCHEDULE SPEEDS AND TRAIN FREQUENCY.

It is a peculiar fact that no other form of machinery, whether used for power generation, power translation, or power utilization, has such high efficiency, such capacity for overload and such flexibility of control as has electrical apparatus. The remarkable speed-and-torque characteristic of the series-wound motor permits of a smooth and rapid rate of acceleration, absolutely under the control of the operator. This rate of acceleration may be practically anything desired, and is accomplished without resorting to excessive power demand or abnormally large motors. The maximum acceleration is usually determined by the comfort of the passengers, and by the slipping of the wheels, and is not limited by energy consumption. Indeed it has been shown that for a given schedule the equipment having the highest rate of acceleration will perform the service with the least energy consumption.

The facility for maximum acceleration, the great capacity for overload, and the high ratio of power to weight, enable the straight electric car to handle successfully and economically higher schedule speeds than any other type of car, no matter how equipped. The steam engine operated car, because of the overload power of the steam engine would probably come next, while the gasoline car, with direct mechanical transmission would, because of the absence of starting torque and of overload capacity of the gasoline engine, fall well below them all.

High accelerating power becomes more important as the number of stops in a given distance increase, and it is this fact, as well as the difficulty of mechanically transmitting power from the gasoline engine to the drivers, which renders combination gasoline electric cars at present the most promising of the self-contained cars.

That system of transportation operating the most frequent trains will obviously best serve the traveling public. The experience with the standard electric cars has demonstrated the public's appreciation of this in the new business which the electrics have built up for themselves. Such frequent train service of the standard electric system is made possible by the fact that practically no power is wasted. The motorman, by the simple manipulation of his controller, utilizes the power only as it is needed, and does not waste energy—that is fuel—when the train is coasting or standing still. Experience of electric roads is such that the starting and stopping of the different train units so dovetail into one another that the load on the central power house is proportional to the average energy consumption per train.

Any system of transportation employing self-contained motive power units must be obviously at a disadvantage in this respect, since fuel consumption must go on all the time the train is in service, whether it is coasting or standing at a station.

CLEANLY AND NOISELESS OPERATION.

The great importance of cleanly and noiseless operation of trains is best evidenced by the action of the New York Central, the New York, New Haven & Hartford, the Pennsylvania, the Long Island R. R. and the Baltimore & Ohio, in electrifying their largest terminals. It is well known that this action was largely brought about by public sentiment. That the builders of self-contained cars appreciate the importance at least of cleanliness is indicated by the fact that nearly all are using oil for fuel, and practically none of them would consider the smoke, cinder and soot producing fuels such as coal, etc. The advantages, if any, are in favor of the standard electric system, for there must always be present some vibration and some exhaust fumes from the engine of the self-powered car.

OPERATING AND MAINTENANCE COSTS.

The absence of actual operating data of self-contained cars does not permit at the present time of a comparison of actual maintenance and operating charges between such cars and the straight electric. It is perfectly logical, however, to expect in view of the complicated mechanism of the former and extreme simplicity of the latter, that the MAINTENANCE CHARGES for the self-contained car system will be greater than for the straight electric. The maintenance cost may reasonably be expected to be about midway between the electric car and the steam locomotive.

The OPERATING COST of the several types of self-contained cars will naturally vary among themselves, but in all instances such costs exclusive of interest on the investments will be materially higher than the straight electric, and in most cases, the costs, including interest charges, will favor the straight electric.

This reasonably follows in view of the high efficiency of the modern power station and transmission systems of electric traction, and also because of the high weight efficiency of electric cars. The independent motor car must not only drag along its own power plant, but it must sacrifice valuable remunerative space in order to carry it. For the same remunerative capacity the self-contained car will weigh from 50% to 100% more than the standard electric car. Under the same conditions of track, speed and distance the energy consumption required to move cars of any sort will vary as their weight, whence it follows that the energy consumption of the self-contained car will be from 50% to 100% greater than the electric car.

The labor expense of practically all types of self-contained cars will be 50% and upwards greater than the straight electric for the reason that in addition to motorman and the conductor, a skilled mechanic is necessary for the operation of the power generating apparatus in each of the self-contained cars. This attendant is usually paid 30 to 40 cts. per hour, or from 50% to 100% higher wages than the ordinary platform man receives.

All self-contained cars, excepting those equipped with storage batteries, must have prime movers of sufficient capacity to suitably accelerate the cars, and since the power required for accelerating is from two to four times that for full speed running, and also because of the intermittent power demand in railway service, it follows that the average load on the prime mover will be but a fraction of its rated power, hence the efficiency of engine operation, whether steam or gasoline, must be low. This condition is worse with gasoline engines,

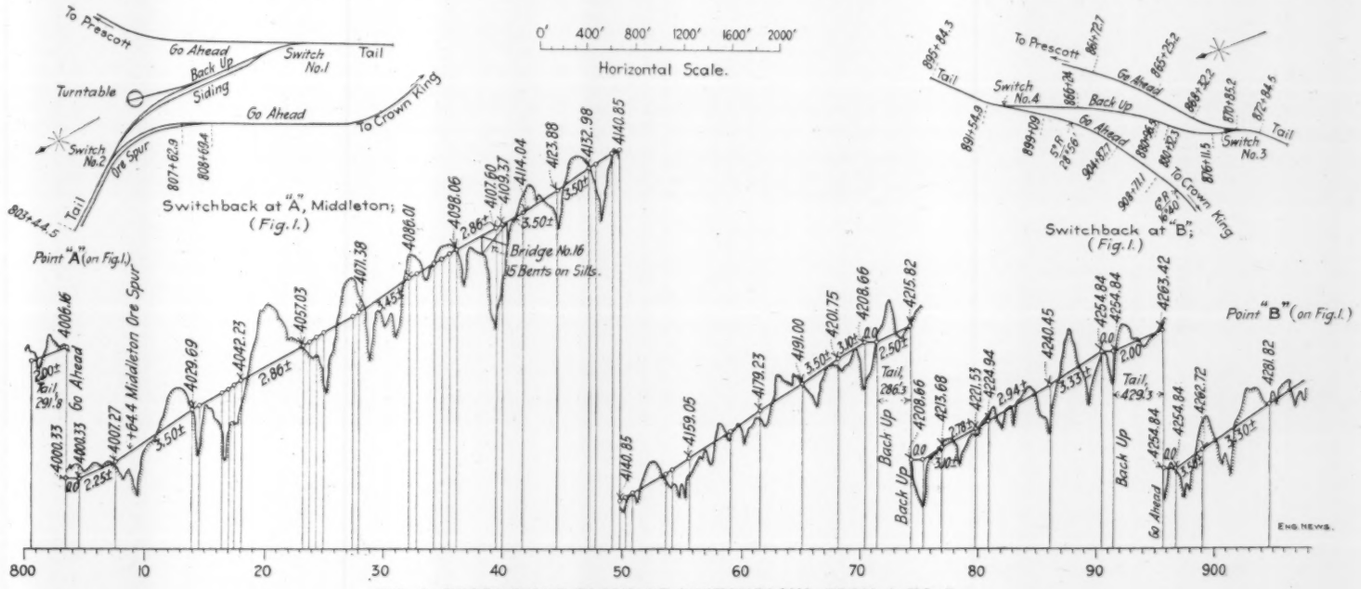


FIG. 2. PROFILE AND PLANS OF SWITCHBACKS FROM A TO B

which have no overload margin, and in many cases, the average load will probably not exceed 40%. Where floating storage battery is carried on the car it is, of course, possible to use a smaller engine and to work it at close to its rating most of the time, and the fuel cost per ton mile of such a car would be somewhat less than of one without battery.

The St. Joseph Valley locomotives with single trailer, during the early days of its operation averaging 66 miles per day consumed 50 gals. of gasoline per day. This worked out per train mile as follows:

Fuel at 16 cts. per gal.	12
Labor, 75 cts. per hour	3.4
Acid, water, waste, sundries	.6
	16 cts.

Mr. H. M. Beardsley published in the Street Railway Journal July 15, 1905, a very complete table of operating statistics of electric roads in New York State. A study of this shows that straight electric operation per car mile is much less than the above figures, and if the comparison be made on the basis of cost per car seat or unit of remunerative space the showing will be still more in favor of the straight electric cars. The averages of ten roads in the table work out as follows:

OPERATION.

Power	2.629
Wages of conductor, motorman	4.146
Car service supplies	.109
Miscellaneous	.16
	7.044 cts.

Comparison between a single concrete case and an average of a lot of widely varying cases while giving an indication is not convincing, therefore, it may be of more interest to compare briefly the requirements and performance of a gasoline electric car, and a straight electric car for transporting a given number of passengers, under the same conditions of distance, time, stops and roadway. Assume a line 25 miles long, standard steam railroad construction, stops of 15 seconds' duration each, to average one every three miles. It is desired to operate a car seating 48 passengers, making the run one way in one hour.

Let us take the Delaware & Hudson car previously mentioned. It has been recently described in the technical press, but no hint of its detailed performance is published, so we must rely upon calculated performance. This car weighs about 125,000 lbs., and the car body, 65 ft. over all, is of the combination type, that is, with passenger and smoking compartments, seating a total of 40 passengers and with baggage express compartment. The engine is at one end, and the motorman's compartments with controlling apparatus at each end for operation of the car in both directions. Power is supplied by a 160 HP. gasoline engine, direct connected to a 120-KW. separately excited generator. A small 5-KW. generator furnishes the excitation. The motor equipment consists of two 200 HP. each, standard railway motors, with two series parallel controllers. The generator output is limited by the capacity of the gasoline engine. The controllers, besides the usual connections for changing motors from series to parallel, also have connections for changing the voltage of the generator through its excitation. The acceleration and speed regulation of the car is then governed by the voltage of the generator and not by the usual method of resistance in series with the motors.

A standard interurban car, about 45 ft. long, will seat comfortably 48 passengers, and will weigh fully equipped 24 to 28 tons. With four 50 HP. motors geared to about 35 to 38 miles per hour, maximum speed, and with normal trolley voltage, such a car will perform very satisfactorily the service outlined.

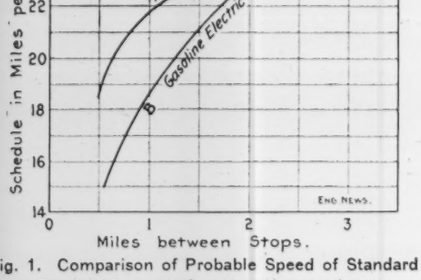


Fig. 1. Comparison of Probable Speed of Standard Electric Car and Gasoline Electric Car.

In Fig. 1 are two curves, showing the schedule performance, which might be expected of the two cars—B referring to the gasoline electric car, and A to the standard interurban car. Incidentally, it is interesting to observe that as the frequency of stops increases, the self-contained car falls much more rapidly away from the schedule than the straight electric. Thus, at one stop per mile it can do 18¾ miles per hour schedule, while the straight electric can do 21¼ m. p. h.

Under the conditions assumed, the rate of energy consumption of the straight electric car will be about 60 watt hours per ton mile, at the motors, and this value will be used as applying to the combination self-powered car, although as a matter of fact, the input to the latter will be somewhat higher owing to its slower rate of acceleration, and would more than offset the elimination of rheostatic losses in the motor control.

Manufacturers of gasoline engines of the size under consideration generally claim 10 HP. hours output per gallon of gasoline at full load, but will guarantee only 8 HP. hrs. per gal. of this fuel. In the calculations which follow, no account will be taken of the rapid falling off in fuel economy at fractional loads, so in using the 8 HP. hr. per gal. value, the error, if any, is in favor of the gasoline outfit.

Electric power station performance is well known from numerous published or otherwise available records. The following is typical of a 4,000-KW. turbine, water-tube boiler plant with coal at $1.60 to $1.80 per ton.

Coal	$ .0034
Labor	.0016
Maintenance	.0007
Supplies	.0003
Cost per KW. hr. at switchboard	$ .006

A well operated plant with fairly good load factor should encounter little difficulty in producing power at this figure; indeed, many show much better results. For the purposes of this discussion, however, a higher figure—$.0085—will be taken. This value is easily attained by most of the interurban power plants in the Middle West.

Transmission efficiencies to the motors will be taken to average as follows:

	A. C. System.	D. C. System.
Step-up transformers	98%	96%
Line	97%	97%
Step-down trans.	96%	96%
Rotary		88%
Car transformer	96%	
Feeder and trolley net work	93½%	89%
Net efficiency	80%	70%

Gasoline Electric Car 62½ Tons.

$62\frac{1}{2} \times 60 = 3.75$ KW. hrs. p. c. m.

$3.75 \times 25 = 94$ KW. avg. per trip.

94 KW. = 78% of 120 KW. the rating of the generator and at this average load, generator efficiency equals 90% approximately.

Then $\frac{3.75}{.746 \times .90} = 5.6$ HP. hrs. p. c. m.

The engine will develop at full load about 8 HP. hrs. per gal. of gasoline.

With fuel at 10 cts. per gal.

Power $\frac{10. \times 5.6}{8} = 7$c. p. c. m.

Car Crew.

Motorman	.21 per hour
Conductor	.21 " "
Mechanic	.33 " "
	.75

$\frac{75}{25} = 3$ cts. per car mile.

Waste, oil, small supplies ..... .60

Straight Electric Car 30 Tons.

$30 \times 60 = 1.80$ KW. hrs. p. c. m.

$1.80 \times 25 = 45$ KW. avg. per trip.

Power at interurban generating station costs $.0085 per KW. hr. at the busses; taking transmission efficiency to the motors at 80% (AC system).

Then $\frac{1.80 \times .0085}{80} = 1.91$ p. c. m.

Car Crew.

Motorman	.21 per hour
Conductor	.21 " "
	.42

$\frac{42}{25} = 1.68$

Allow for substation attendance ..... .01

1.69 p. c. m.

Waste, oil, small supplies ..... .55

SUMMARY.

7.00	Power	1.91
3	Labor	1.69
.6	Supplies	.55
10.60	Per car mile	4.15

These are comparative costs per car mile, exclusive of maintenance and of general expense, and are subject to considerable variation under varying conditions. The Union Pacific car, which weighs about 29 tons, has unofficially been stated to consume ½ gal. gasoline per car mile in service, involving much fewer stops. The Strang gasoline storage battery car, weighing approximately 37 tons, consumes, according to official statements of the builders, $^{45}/_{100}$ gal. gasoline per car mile. No statement of service conditions is given, but it is inferentially taken from the run from Philadelphia to Kansas City, where the stops were very infrequent, probably less than 1 in 20 miles.

As a check on the above calculations this data is interesting. The gasoline consumption per ton mile works about as follows:

D. & H. Car	.0112 gal.
U. P. "	.0168 "
Strang "	.0118 "

It is not intended to compare these three types of independent motor cars, for such comparison would be manifestly unfair, unless one took into account all the factors entering into the construction and operation of each of the cars. It is intended to show, however, that the calculated performance of the D. & H. car includes a margin favoring the independent motor car as compared with the standard electric.

INITIAL INVESTMENTS.

To get down to the gist of the whole problem and to see the influence of the initial investments on a given proposition, we will investigate two cases; the first between the gasoline electric and the standard electric, and the second between these and steam railway service.

The first proposition contemplates the average interurban condition, and may represent, if you will, the competition between two parallel roads for the local passenger and light traffic business, which is assumed to demand cars at one hour headway from 6 A. M. until 12 P. M., or 18 hours' service. The items of cost and maintenance common to both roads will not enter into the present consideration, and we will assume that the general expense of administration, engineering, taxes, insurance, etc., will be the same in both. We will take the same service conditions as before, i. e., 25 miles of road, stops every 3 miles and 1 hour for the run.

The single-phase system is well adapted to such service and will be considered in the following. It would be entirely feasible to operate with a generating plant in the center of the line feeding 6,600 volts directly into the trolley, eliminating high tension transmission and substation and thereby effect a saving in the assumed case of approximately $18,000. But it might be necessary because of water supply, coal, etc., to build the power house at one end of the line and thus necessitate a substation. In order to be entirely fair to the gasoline car, let us assume this extreme condition.

Two cars will normally handle the service, but for special days requiring half hour headway and for reserve, four motor cars and two trailers will be purchased. The normal daily mileage will be 900.

Estimated Cost of Straight Electric System.	
Power plant	$45,000
One substation	2,000
Distribution system	48,000
4 motor cars, 2 trailers	36,000
Rail bonding	6,250
	$137,250
Interest and depreciation at 10%, or, $37.60 per day.	13,725
Estimated Cost of Gasoline Electric System.	
4 motor cars @ $17,000	$68,000.00
2 trailers @ 3,000	6,000.00
	$74,000.00
Interest and depreciation at 10%, or, $20.30 per day.	7,400.00

The maintenance of electric cars and plants per car mile can be gotten fairly well from the many published records, but that of the self-powered cars is at present a matter of guess. It will be taken at 4 cts. per car mile, which is, roughly, one-half the average maintenance charges of steam locomotives per mile.

	Gasoline Electric.	Standard Electric.
Power	7.	1.91
Car crews	3.	1.68
Supplies	.6	.55
Maintenance equipment and cars	4.	1.5
Maintenance plant and distribution system		.5
Operating cost per car mile	14.6	6.05
Daily Cost.		
Operation	$131.40	$54.45
Interest and depreciation	20.30	37.60
	$151.70	$92.05

Thus, the difference in favor of the straight electric under the conditions assumed would be $59.65 per day or approximately $22,000 per year.

Consider now, an existing branch of a steam road where the passenger traffic is light. Service must be given even if without profit, indeed many such branch lines are now operated at a loss, so far as the passenger and light traffic is concerned. The problem then is to find the cheapest means of handling the business.

Let us take the same length of line, frequency of stops, etc., as before, but that four trains each way per day will handle the business. We will assume that the train crews when not on the passenger runs are kept employed elsewhere on the system. The steam service would call for two light locomotives and four passenger combination cars. The self-powered and the straight electric would each require two motor cars and two trailers. The trailers would not be used during the normal service, but would have to be purchased and kept to meet the demands of Sundays and special days.

It is assumed that the roundhouse, repair shop and water tanks would about balance the cost of electric car barn and repair shop. Omitting, then, as before, all factors of cost and operation common to all three systems, we will have:

Estimated Investment for Steam Service.

2 45-ton locomotives with tenders	$16,000.00
4 passenger coaches	16,000.00
	$32,000.00
Interest and depreciation at 10%..... or, $8.78 per day.	3,200.00

Estimated Investment for Straight Electric Service.

Power plant	$27,000.00
Substations	1,500.00
Distribution system	48,000.00
2 motor cars } 2 trailers }	21,000.00
Rail bonding	6,250.00
	$103,750.00
Interest and depreciation at 10%..... or, $28.50 per day.	10,375.00

A plant of this size would not produce power so cheaply as the larger ones previously considered. The cost per KW. hr. is taken at 1½ cts. per KW. hour, whence we have:

Power	3.38c.
Labor (as before)	1.69
Supplies "	.55
Maintenance (as before)	2.
	7.62c. per car mile

Estimated Investment Gasoline Electric Service.

2 gasoline electric cars	$34,000.00
2 trailers	6,000.00
	$40,000.00
Interest and depreciation at 10%..... or, $10.90 per day.	4,000.00

The steam train will consist of the locomotive, tender and two cars, giving a train weight of approximately 110 tons; under the assumed conditions of schedule, stops, weight, etc., such trains will require about 35 watt hrs. per ton mile, i. e., .0745 HP. per ton mile. In such service, the locomotive would burn about 7 lbs. of coal per HP. hr., and if this coal cost $2.25 per ton, the train mile cost would be approximately:

Train Crew.

Engineer	.35	per hour
Fireman	.21	"
Conductor	.30	"
Brakeman	.175	"
	$1.035	"
Power	6.35	
Maintenance locomotive and cars	8.	
Supplies	2.	
Round house exp.	1.	
Train crew	4.15	
	21.5c. per train mile	

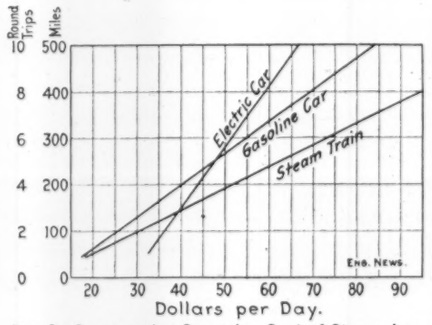


Fig. 2. Comparative Operating Cost of Steam, Locomotive, Electric and Gasoline Systems of Passenger Transportation.

The daily operating costs, exclusive of those items which are common to all the systems, would then be:

	Steam.	Electric.	Gasoline.
Operation	$43.00	$15.34	$29.20
Int. and depreciation	8.78	28.50	10.00
Total	$51.78	$43.74	$40.10

As the same equipment, and, therefore, the same investment, would be needed for a few trips more or less, and applying the same unit operating costs per car mile and the same fixed charges, we get the following:

Daily round trips.	Mileage.	Steam.	Electric.	Gasoline.
Six	300	$73.29	$51.36	$54.70
Five	250	62.53	47.55	47.40
Four	200	51.78	43.74	40.10
Three	150	41.03	39.93	32.80
Two	100	30.28	36.12	25.50
One	50	19.53	32.31	18.20

This brings out clearly, that in the assumed case, the gasoline car is cheapest under six round trips per day, while the electric system is the cheapest at six trips or more per day.

Generally speaking, the gasoline car will show a saving over the steam train in light, infrequent service, but when the frequency begins to approximate 2½-hour headway between trains, the electric car is undoubtedly the cheapest and becomes increasingly so with increase of traffic frequency.

EXTERNAL TRANSMISSION CIRCUITS.

We come now to what probably more than any other factor, including even higher initial investment, has been the greatest stumbling block to the electrification of steam railroads. All other details of electric railroading have easily surmounted the objection of the steam railroad men; it is not the purpose to discuss the important subject of external transmission circuits within the limits of this paper, but it is well to point out that the progressive men in heavy railroad work no longer look upon the electrical power conductor with the doubt and misgiving, not to say scorn, with which they regarded it a few years ago. The overhead trolley has demonstrated its reliability and sturdiness on thousands of miles of electric roads from Maine to California, from the Lakes to the Gulf, in all conditions of weather and seasons. But until very recently, low trolley voltage limited its use to light interurban service. The writer is quite in sympathy with the railroad men's objection to the third rail, which, while it has splendidly performed its functions of showing the possibilities of heavy traction—is for many reasons inadvisable for surface work, although well adapted for subway or elevated roads. The advent of the single-phase system, permitting the use of high trolley voltages, and hence moderate power conductors and bow trolleys, has brought the overhead trolley conductor into the field of heavy railroading, and with the large Eastern roads setting the pace the early electrification of the present steam lines will inevitably come on.

CONCLUSION.

Managers of steam railroads entrusted with the direction of large vested interests, are naturally very conservative and therefore slow to make what would appear to be radical changes in their equipment. Therefore, while they realize the limitations of the steam locomotive in suburban and interurban service, they will, before stringing the trolley wire over their tracks, try out pretty thoroughly the independent motor car, which holds out alluringly the suggestions of interurban service without the power-house, without the track bonding and without the external transmission circuit. This try-out will definitely establish the true field of the self-contained car, and, in the writer's judgment, this field will be the very short spurs of existing steam railroads, serving sparse population, making infrequent trips principally to connect with main lines. Take one road—the Burlington for example; the Galena Junction shuttle train operating on a five-mile spur, and meeting the more important trains of the main line; and the Dubuque shuttle train which operates on the mile and a quarter spur from East Dubuque over the Mississippi River Bridge—these could well use such independent motor cars; unless, indeed, electric power at satisfactory rates can be purchased of the neighboring electric companies.

There is another field, not very wide it is true, but a profitable field which the independent motor car may enjoy with freedom from competition. The writer expects to see the present private cars of our millionaires displaced by the independent motor car, which can be made as comfortable and luxurious as any of the Pullmans now in service. Their owners may go anywhere that standard gage tracks lead to, regardless of limitations to locomotives or to electric cars.

As to prospective interurban roads which are promoted with the view to using the gasoline or other types of independent motor, it is highly desirable to go slow and investigate. Broadly speaking, if a prospective road is to depend for revenue only on its passenger and light express traffic, and the business only warrants 1½ or more hours headway between cars, it becomes very much of a question whether or not the road will pay or ought to be built at all.

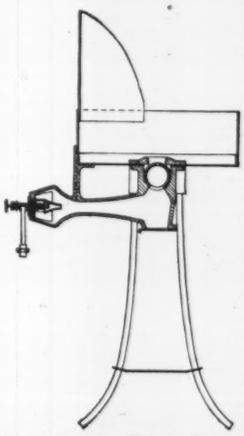
But this brings us into the realm of interurban railway economics, concerning which much less even than railway engineering it is not well to generalize. Each individual proposition should be independently examined and passed upon by a competent engineer, who should determine the equipment best fitted for it.

In city service, the independent gasoline car will find only the remotest application. Under certain conditions of power plant arrangement and operation, there may be isolated instances where the independent car might be called upon to handle the "Owl" service in the small hours of the morning. It may also be used on streets on which the municipality prohibits the laying of tracks. Indeed, such cars are already in operation on Fifth Ave., New York. In such service, the independent car will probably displace the so-called "trackless" trolley cars, which are in use in some of the European cities.

In conclusion, the writer believes that the independent motor car will prove a useful transportation medium. Its field will be distinct from that served by the standard electric system. The likelihood of the independent motor cars becoming serious competitors of the electric cars is quite remote. Reduction in operating cost of the independent car must come about through cheaper fuel and smaller labor expense. As we all know, the price of gasoline is constantly increasing, due to the diminishing supply of the crude oil from which it is made. Kerosene engines and alcohol engines are frequently spoken of, but as yet can not compete with the gasoline engines. The reduction in labor expense is not very promising. Advances and improvement in the art of independent motor car will undoubtedly be made, but at the same time it must be borne in mind that the electric system will by no means stand still, and if its future progress be judged by that of the past, it will undoubtedly become the pre-eminent transportation medium.

A PORTABLE RIVET-HEATING FORGE OPERATED BY COMPRESSED AIR.

The accompanying sketch shows the application of compressed air to a portable rivet-heating forge. In this forge the air is admitted by a needle valve through two brass nozzles into a cast iron mixer nozzle and thence direct into the tuyere. The claim is that by the use of the needle valve the volume of air is varied without reducing the pressure, while the compounding reduces the total volume of air required about one-half. Another design of forge is made in which the air acts directly on the blast fan, but the makers advise that the design illustrated be chosen, as extensive experiments show great economy in using the direct pressure blower. It is stated that the jet design of blower requires only one-ninth the current of air to operate the forge that is required by the blast fan design; also that the jet blower operates the forge with one-fortieth the air that is required to operate a free air forge with an ordinary blower. The forge illustrated, as well as forges in which the compressed air operates a fan blower, are made by the Buffalo Forge Co., of Buffalo, N. Y.



Rivet-Heating Forge Operated by Compressed Air.

ANNUAL CONVENTION OF THE MASTER CAR BUILDERS' ASSOCIATION AT ATLANTIC CITY, N. J.

Opening Session.

The Master Car Builders' Association held its 40th annual convention at Atlantic City, N. J., on June 13, 14 and 15, with one of the largest attendances of members and guests ever recorded. Contrary to the usual custom no headquarters hotel was appointed, so that the members attending were widely scattered, and perhaps did not enjoy quite as fully as usual the verandah conferences that have come to be one of the most valuable features of their meeting together each year. If this were the case, however, the formal meetings perhaps gained in attendance and in attention to the work in hand. It is certain at least that few meetings have shown a closer attention to work than this last. As for that feature of the convention known as the "Exhibit" of railway motive power supplies and appliances, it was confessedly bigger and better and more handsomely presented than ever before. Like the convention hall, the exhibits were located on the Steel Pier, this great structure having been in fact practically preëmpted for convention purposes.

BUSINESS PROCEEDINGS.

The convention was opened by an address of welcome from Mayor F. P. Stoy, of Atlantic City, which was acknowledged on behalf of the visitors by Mr. Geo. A. Post. In the customary annual address of the President, which followed, Mr. Joseph Buker referred to the growth of the association and of the interests which it represented, and urged unstinted attention to the work before the convention. Having regard to the promises of the future he urged the members to study seriously the development of motor car service for suburban and branch lines. There would, he thought, be a constantly increasing and permanent demand for such service, and it was upon the mechanical department that the duty fell of

working out the type of car and the method of generating and applying power for its operation. The report of the Secretary and the Treasurer, and the appointment of committees on nominations, resolutions and accounts completed the routine proceedings of the session.

SPECIAL EXECUTIVE COMMITTEE REPORT.—Referring to the action of the Ohio General Assembly of 1906 in passing a law in which it is required that "each and every car used in the movement of state traffic shall be provided with secure sill steps on each end of each side thereof," the Executive Committee presented a resolution of the association protesting "against the enactment or enforcement of legislation by any state which is calculated to destroy the uniformity of equipment so necessary to safety and the expeditious interchange of cars." In the preamble to this resolution and in the discussion which followed its presentation it was pointed out that the work of the association had always been toward increasing safety of operation, that its present standards regarding sill steps, ladders and grab irons had been adopted because they were considered to be the safest in number and type, that the Interstate Commerce Commission had tacitly approved these standards in ordering all inspection to be based on them, and that cars equipped to meet the Ohio law were being refused in interchange because of departure from the standard. It was in view of these reasons that the resolution was urged, with the hope that it might discourage in the future similar state legislation unsupported by the Interstate Commerce Commission and disapproved by the Master Car Builders' Association. The resolution was passed by vote of the convention.

CHANGES IN THE CONSTITUTION.—By vote of the convention Section 2, Article III., of the Constitution, was changed as proposed at the last meeting to enlarge the scope of membership, and Section 5, Article II, was changed to permit election to life membership of any member who had been in good standing for 20 years. Mr. G. W. Rhodes was proposed as life member and elected by vote of the convention.

ADDRESS BY EDWARD A. MOSELEY.—At the invitation of the President, Mr. Edward A. Moseley, Secretary, Interstate Commerce Commission, addressed the convention. The speaker congratulated the association on the continued progress shown by inspection in the equipment and the keeping in proper condition of safety appliances on cars. As stated by the inspectors' reports, the number of cars under inspection in 1905 was 44,000 greater than in 1904, but the total number of defects noted was 8,000 less in 1905 than in 1904. The percentage of defective cars to the number of cars inspected was 22.59% in 1905, as against 31.31% in 1904. It seemed quite certain that the record of the present year would show a further reduction in defects. Despite this good showing there were still features needing improvement. One of them was the hauling of cars with drawbar pulled out by chaining them together; this was a direct violation of the law and one from which the Interstate Commerce Commission would grant no immunity. Improvements were needed in regard to couplers. At present men were unlawfully required to go between cars in coupling and uncoupling because the M. C. B. coupler in use did not operate on sharp curves. Again cases were frequent where the application of improper parts in repair made it necessary for men to go between cars to adjust these parts for operation. Advance was being made in the equipment of cars with air-brakes, and it seemed certain that all companies would be ready to meet the 75% minimum which went into effect on Aug. 1. Something should, however, be done to reduce the number of cars "cut out" because of defects in air-brakes. In respect to safety appliances generally, as, for example, in respect to the sill steps spoken of in the Ohio law just mentioned, the Commission unhesitatingly indorsed the M. C. B. standards.

TECHNICAL COMMITTEE REPORTS.

The Committee on Revision of Standards and Recommended Practice suggested a number of changes, generally of minor character, which, by vote of the convention, were referred to letter ballot for adoption or were placed in the hands of special committees for further investigation and report. The Committee on a Composite Design of Coupler reported in brief that such a coupler was impracticable. It was impossible to design any coupler containing the best features of existing couplers without infringing existing valid patents, and as coupler manufacturers refused to give up their patent rights and surrender them to the association the work was at once blocked. The report was accepted and the committee was discharged. The Committee on Triple Valve Tests reported the test of one valve submitted by the Westinghouse Air Brake Co. This valve, which is designed for freight equipment, contains three principal features not found in valves previously tested by the committee as follows: (1) a quick service application, (2) a retarded release, and (3) a retarded recharge. The report described the construction of the valve in detail and gave a full record of the tests made. The report concluded with the opinion that a new code of tests should be compiled for 75 and 100 car trains, and with a recommendation that the testing rack at Purdue University be redesigned to allow of testing as many as 100 brakes with either 8-in. or 10-in. equipment. By vote of the convention the enlargement of the testing rack was authorized and a committee was appointed to devise a code of rules for testing trains of 75 to 100 triples.

CAST IRON WHEELS.—The subject of cast iron car wheels received the attention both of the standing committee and of a special discussion opened by Mr. Geo. L. Fowler. The committee submitted for approval the following changes in the present standard wheel: "An increase of 1/8 in. on the flange and a change in the taper of the tread from 1 in 25 to 1 in 20. These changes call for an addition of 15 lbs. to each weight of wheel, making the minimum weights 600, 650 and 700 lbs. Included in the report was a statement from Committee on Standard Rail and Wheel Sections of the American Railway Association that the wheel as changed would pass the present frog and guard rail clearances without difficulty. The discussion of the report turned upon three questions: (1) Can the changes recommended be made without fear of interference by the American Railway Association? The answer was made by the chairman of the committee that conference with the American Railway Association had definitely settled this question; the new wheel would not be objected to. (2) What effect would the increased taper of tread have upon track? Mr. C. A. Schroyer (Chic. & No'w'n) thought that while the increased taper would ease up on the wheel flange it would also give an increased outward pressure on the rail head which might be troublesome. He cited the fact that in the West there were many miles of track that had light narrow based rails on soft wood ties in soft ballast, and it was quite credible that such track might be seriously effected by the push of the increased taper. Answering this point Mr. R. L. Ettenger (Sou. Ry.) stated that a number of railways had experimented with a taper greater than 1 in 25, and had reported no effects on track and a tendency to keep the wheels between the rails a little better. (3) Will the enlargement of the throat radius between flange and tread have a tendency to increase derailments. Mr. C. A. Schroyer (Chic. & No'w'n) considered that the greater the radius the more liability there is for the wheels to climb the rails. Mr. J. J. Hennessey (C., M. & St. P.) did not believe that an increased radius would increase derailments. He was using a wheel with large throat radius and had experienced no marked trouble from derailments. The discussion was closed by vote to submit the recommended changes to letter-ballot as recommended practice. The special discussion by Mr. Geo. L. Fowler took up the subject of the circumferential variation allowable in mating wheels. Theoretically, both wheels should be of exactly the same diameter, but this was impracticable. Practice ran from 1/32-in. to 1/8-in. variation. No additional information was brought out by the discussion.

Second Session.

The second day of the convention was, as usual, devoted to a consideration of the rules of interchange and in such time as was left from this official work to the reading and discussion of committee reports. Fortunately, the rules of interchange were quickly disposed of; a number of changes were recommended by the Arbitration Committee, and these were adopted without discussion by vote of the convention.

BRAKE SHOE TESTS.—The standing committee on Brake Shoe Tests reported the results of tests on 100 brake shoes submitted by nine different railways. As a complete log of the tests of each shoe was given the report was a long one and naturally of special rather than general interest. Roughly, the results may be summarized as follows: (1) Shoes taken from service have in most cases met the requirements with reference to the mean coefficient of friction to be developed during a stop. (2) Shoes taken from service have in most cases failed to meet requirements with reference to the rise in the coefficient of friction at a point 15 ft. from the end of the stops. (3) Shoes are now in service which give a coefficient of friction so much in excess of the minimum specified as to permit great variation in braking effect. The logic of this situation would seem to require either that the present specification be raised, or that a maximum coefficient as well as a minimum be specified. The committee also recommended that the question of adding such apparatus to the testing machine as would permit wearing tests to be made be referred to the executive committee.

The first point brought out in the discussion was the desirability of having added to the other test data, analyses showing the composition of the various shoes tested. The addition of these data was urged by Mr. R. P. C. Sanderson (S. A. L.) on the basis that only by having such records could a company determine whether in buying shoes it were getting exactly the same kind and quality of shoe as had been tested. In answer it was pointed out by Prof. W. F. M. Goss of the committee that such analysis would be expensive and that, as every tested shoe was on file in the laboratory, a railway that had any doubts as to the genuineness of their purchase could by payment of costs have an analysis made of the test shoe for their use. Mr. Geo. L. Fowler supported Mr. Sanderson in his desire to see analysis added to the test-data, but considered that there was a more pressing necessity in doing something to establish a maximum as well as a minimum coefficient of friction. He pointed out that great care had been taken to secure absolutely uniform action of all triple valves so that surgings of the train would be prevented in applying brakes. If now brake shoes of widely varying coefficients of friction were to be allowed this uniformity of brake action sought by making the triples uniform would be nullified. In this contention Mr. Fowler was supported by Mr. T. W. Demarest (P. R. R.) and by Mr. F. H. Clark (C., B. & Q.), and on motion of Mr. Clark the convention authorized by vote that the committee be instructed to determine a maximum and a minimum specified coefficient of friction for brake shoes. It was also voted to refer the question of making additions to the testing machine for wearing tests to the Executive Committee with the recommendation that these additions be authorized.

BRAKE BEAMS.—The report of the committee on this subject was printed nearly in full in our last issue, and need not be reviewed here. The discussion following the report resulted in a vote to refer the recommendations of the Brake Beam Committee to the standing Committee on Standards, to be reported upon next year. Previous to this action, however, a number of criticisms were brought out by different members which deserve brief mention. Mr. Geo. L. Fowler noted that recommendation No. 50 called for an angle of 90°; he had found it necessary to ex-

ceed this angle slightly in order to keep always a clearance between loose shoe and wheel, and this was also recommended by the Westinghouse Air Brake Co. Mr. N. H. Davis (Davis Pressed Steel Co.) noted that the kind of steel to be used for brake beams, whether open hearth or Bessemer, was not specified; this question might well be considered. He also stated that the specified requirement of 9½ ins. from center of pin hole to back of beam could not be met by the beams made by his company; there were 10 ins. in this dimension and could not be made less. Mr. S. A. Crowe (Buffalo Brake Beam Co.) also stated that the beams made by his company could not comply with the 9½-in. dimension. Mr. A. E. Mitchell (L. V.) stated, as chairman of the committee that he thought that this dimension should be changed. Mr. G. W. Wilden (Erie) announced that the reason in checking up a large number of cars it was found that a 9½-in. beam was the maximum size that would go in, and in many cases this was too large.

MISCELLANEOUS REPORTS.—The report of the Committee on Axle Limits referred to a method of marking cars so as to secure as nearly as possible a reconciliation between the Association's standards and the Rules of Interchange respecting the replacing of axles. Its recommendations changing Rules 23 and 74 of the code were adopted. The committees on Rules for Loading Long Materials and on Location of Temporary Stake Pockets proposed various changes in the present practice. Both were referred by vote of the convention to letter-ballot for approval. In connection with the report on loading long materials, however, it may be noted that a very strenuous discussion developed from the recommendation that superimposed loads be limited in height to 9 ft. 3 ins. This limitation was vigorously objected to by a number of the members, and finally it was cut out of the report as sent to letter-ballot. The Rules for Passenger Car Interchange were adopted as changed by the report of the Arbitration Committee.

Closing Session.

The closing day's session of the convention was a short one. Most of the committee reports were short and the business session confined to the election of officers, always a task quickly finished with this Association.

AIR-BRAKE HOSE SPECIFICATIONS.—The report of this committee was in effect a report of progress. The investigations of the committee led it to believe that a chemical standard should be set for rubber used in hose, and that in time the bursting pressure and chemical analysis should make up the specifications for hose. The committee was not yet prepared to draw such varied specifications and, therefore, left this matter practically where it was. The discussion which followed consisted largely in further explanation of the report in response to members' questions. The consideration of the report was closed by a vote of the convention authorizing the appointment of a committee to investigate and report on the chemical composition of rubber for air-brake hose.

AUTOMATIC HOSE CONNECTORS.—The committee reported in substance that there were two types of connectors in use, the butt joint or butt post connector and the lap joint or side post connector. The patents of the side post device were controlled by one company, and would prevent others making a connector similarly posted. The butt post type of connector was made by four companies, and interchangeability could be readily accomplished. The committee did not feel warranted in recommending either type as standard, and suggested that it be continued to prepare standard dimensions, etc., for connectors of the butt type. By vote of the convention the committee was continued, but discussion previous to the vote brought out the statement by Mr. A. L. Humphrey (Westinghouse Air Brake Co.) that the basic patents on both butt and side post connectors had been outlawed and any manufacturer could use either principle so long as he did not infringe certain patented specified features of connectors of both types now on the marked. In view of this explanation the vote for continuing the committee carried with it the intention that the committee should investigate both side and butt post devices, and not butt post devices only.

OTHER REPORTS.—The Committee on Side and End Ladders for box cars presented a report recommending that the "Committee on Standards be instructed to modify the M. C. B. sheets and rules covering the location of grab iron to show the roof grab irons parallel to the side or end of the car on which the ladders are located, these grab irons to be placed not less than 15 ins. from the edge of the car and to be of a length suited to the construction of the car." By vote of the convention the recommendation was ordered submitted to letter-ballot for approval. The Committee on Tank Cars presented general specifications for tank cars which were ordered submitted to letter-ballot by vote of the convention. The Committee on High Speed Brakes reported that it found the gear for four-wheeled trucks satisfactory and was at work developing a gear for six-wheeled trucks; it asked to be continued to complete its work. Progress reports were received from the committees on Height of Brake Staff and Clearances for the Third Rail System.

ELECTION OF OFFICERS.

The closing business session of the convention for the election of officers and routine resolutions and motions occupied only a few minutes. The ballot for officers resulted in the following elections: President, W. E. Fowler, Canadian Pacific Ry.; First Vice-President, G. N. Dow, Lake Shore & Michigan Southern Ry.; Second Vice-President, R. F. McKenna, Delaware, Lackawanna & Western R. R.; Third Vice-President, R. W. Burnett, Erie R. R.; Treasurer, John Kirby; vacancies on Executive Committee, J. F. Walsh, F. N. Hibbitts, F. T. Hyndman.

A DIAGRAM FOR BRIDGE LATERALS.

By O. W. Childs,* M. Am. Soc. C. E.

The accompanying diagram is designed to enable the user to read off the proper size of lateral rod for any panel of any length and roadway within the limits for which the diagram is constructed. To compute the proper size of laterals for a single span requires but a small amount of time, but when a considerable number of spans are to be designed or checked over this diagram will save a great amount of figuring and materially decrease the chances of error.

The diagram is constructed to cover the usual range of highway bridges, but is easily modified or extended to cover a greater variation of lengths and roadways; also to include angles or other sections for laterals at any unit stress desired.

The panel lengths and roadways are both laid off to the same scale—¾-in. = 1 ft. being a convenient size. The divisions along the vertical at the left are laid off to a much smaller scale—1 in. = 20 ft. and 1 in. = 3,000 lbs. making a convenient sized diagram. On this vertical line the scales of length and load correspond to 150 lbs. per ft., which is the wind load assumed for the unloaded chord. The capacities of the various rods at the desired unit stress are then marked off on this line at the scale of pounds assumed, and arcs of circles are drawn to the right through the diagram, using the zero point of the vertical scale as the center, and diagonal lines are drawn from the zero point to the various panel lengths and roadways.

Diagonals are shown in the diagram for 16-ft. roadway only, as more diagonals would overload the diagram; but a triangle or thread may be easily placed across the diagram in order to use it for any combination not covered by the lines drawn.

The diagram is to be used in connection with the two small tables appended to it, which give the stress factors for the various panels of bridges of any number of pounds. Specific instructions for using are given below the diagram.

It will be noted that only rods (round and square) are given by the diagram as shown, but it is an easy matter to add the circular arcs representing various sizes of angle laterals. The design of angle laterals depends on the assumptions made by the designer—the unit stress, the use of one or both legs of the angle in computing the stress, and the division of stress between the tension and the compression diagonal. The location of the arcs for angle diagonals will therefore depend greatly on individual preferences. For this reason and to avoid cumbering the diagram with many lines the curves for rods only are given.

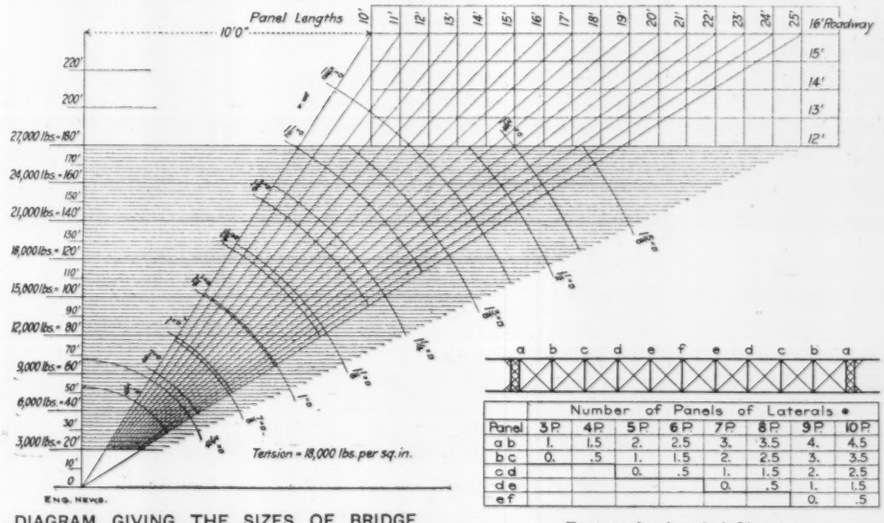


DIAGRAM GIVING THE SIZES OF BRIDGE LATERALS.

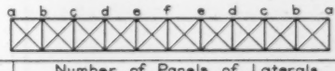
O. W. Childs, M. Am. Soc. C. E.

To Find the Size of Lateral for any Panel.—Multiply the panel-length by the factor given in one of the small tables. Take this result, in feet, on the vertical line at the left of the diagram. Follow the horizontal line from there to its intersection with the diagonal line running to the point in the set of horizontal scales which represents the panel-length and width between trusses. The first circular arc outside of this intersection represents the rod required.

	Number of Panels of Laterals *							
Panel	3 P.	4 P.	5 P.	6 P.	7 P.	8 P.	9 P.	10 P.
a b	1.	1.5	2.	2.5	3.	3.5	4.	4.5
b c	0.	.5	1.	1.5	2.	2.5	3.	3.5
c d			0.	.5	1.	1.5	2.	2.5
d e					0.	.5	1.	1.5
e f							0.	.5

Factors for Loaded Chord.

Uniform Load, 150 lbs. per Lin. Ft. of Span.
Moving Load, 150 lbs. per Lin. Ft. of Span.



	Number of Panels of Laterals							
Panel	3 P.	4 P.	5 P.	6 P.	7 P.	8 P.	9 P.	10 P.
a b	2.	3.	4.	5.	6.	7.	8.	9.
b c	⅓	2¼	2.2	3⅛	4½	5⅛	6⅛	7.1
c d			.6	1.5	2⅓	3⅓	4⅓	5.3
d e					⅔	1¼	2⅔	3.6
e f							1⅓	2.

Factors for Unloaded Chord.

Uniform Load, 150 lbs. per Lin. Ft. of Span.

*City Bridge Engineer, City Hall, St. Louis, Mo.

*This refers to number of panels of *laterals*, not to total number of panels in bridge. For example, in most cases a 12-panel bridge has 10 panels of laterals in the unloaded chord.

THE EFFECT OF THE SAN FRANCISCO EARTHQUAKE ON A REINFORCED CONCRETE FLOOR SLAB.

By C. E. Day.*

In a two-story and basement brick building, for the storage of wine, recently completed for the California Wine Association, located on Townsend St., near Third St., and just outside the fire belt, in San Francisco, is to be found a very rare and illustrative example of the resistance which reinforced concrete construction offers to earthquake shocks and to suddenly applied loads.

The building is of class B construction, in which the floor loads are carried by the exterior wall and intermediate cast-iron columns. The steel box girders which carry the floor slabs are bolted to the columns, so that the building receives its lateral stability only from its inertia and the resistance of the walls. The column panels are 17 ft. 6 ins., and the girders have a span of 19 ft. 3 ins.

The floor system is of the ordinary reinforced slab construction with intermediate reinforced concrete beams, spaced about 5 ft. c. to c., extending between the box girders. The floor beams are reinforced with five 1-in. corrugated bars, two being straight throughout and three being bent near the supports to take the vertical shear. Two of the shear rods are hooked over the girders, and the third one extends into the 4-in. slab.

At the time of the earthquake shock the side wall collapsed between the vertical lines at the outer limits of two of the window arches. In falling the wall not only left the girder unsupported, but with its mass tore the girder from the slab, and, in so doing, tore out the reinforcing in the floor beams and split the beams throughout their length.

The two accompanying pictures, the one an exterior view and the other an interior view, show quite clearly how the beams were split in the plane of the reinforcing, leaving that part of the beam intact which is supported above that shear rod which extends into the slab. The slab as it stands now spans a distance of 35 ft., and is deflected probably 4 ins. On the floor above, not shown in the picture, where the mass of brick was not sufficient to tear the girder from the slab, the girder remains suspended by the slab and appears to be in perfect condition.

*2217 Dwight Way, Berkeley, Cal.

SCREW SPIKES AND WOODEN TIE-PLATES FOR RAILWAY TRACK.

The advantages of screw spikes over the common drive spike for fastening rails to ties have long been recognized abroad, but in this country they have not been used to any extent, although numerous trials have been made, and they are also now being used experimentally on several railways. The ordinary spike has been improved to some extent by sharpening the point so as to cause less damage to the wood fibers, but in any case it must depend upon the friction of these fibers against the body of the spike to resist the pulling force exerted by every wheel that passes, and experience has fully shown that under modern conditions of heavy engines and traffic this friction is not sufficient to hold the rail tightly and permanently to the tie. The most extensive use of the screw spike in this country is on the South Side Elevated Ry., of Chicago, where it is the standard fastening, the spikes being manufactured by the American Iron & Steel Mfg. Co., of Lebanon, Pa. Pulling tests were made with these spikes at Purdue University, the spikes being screwed into holes $\frac{5}{8}$-in. diameter, or the diameter of the spike at the root of the thread. The averages of several tests were as follows:

	Screw spike. lbs.	Common spike. lbs.
Loblolly pine	8,504	3,474
Chestnut	9,418	2,980
Longleaf pine	10,558	2,296
Oak	11,240	4,342
White oak	13,026	6,950

An interesting experiment on a large scale is about to be made by the Pennsylvania Lines (Southwest System, P. C. C. & St. L. Ry.), using screw spikes with the Thiollier special steel lining or sleeve. This fastening is the invention of Mr. J. Thiollier, Engineer, of Paris, France, and was included in the interesting French railway exhibit at the St. Louis Exhibition in 1904. The purpose of the experiment is to determine the additional life which may be obtained from ties of inferior wood by the use of improved fastenings, and for particulars we are indebted to Mr. W. C. Cushing, Chief Engineer of Maintenance of Way of the Southwest System, Pennsylvania Lines. For this experiment, 6,000 ties have been bored and creosoted by the Columbia Creosoting Co., of Shirley, Ind. The ties are bored before being creosoted, and in this case were bored by hand, but for commercial purposes the boring would be done by machine (as is the practice in Europe), and the cost of this is estimated at 2 cts. per tie. After the hole has been bored, it is tapped with a spiral groove, and a spiral steel lining is then screwed into this groove, the coils being compressed or closed together. When the rail is in place, the screw spike is screwed into the hole, its sharp V thread cutting into the solid wood between the coils of the spiral lining. The tapping is only carried to a certain depth in the hole, so that the lining will have a solid bearing at the bottom. In this case the ties are 9 × 7 ins., 8½ ft. long, and ½-in. holes are bored through the tie, while the tapping reaches to a depth of 4⅞ ins.

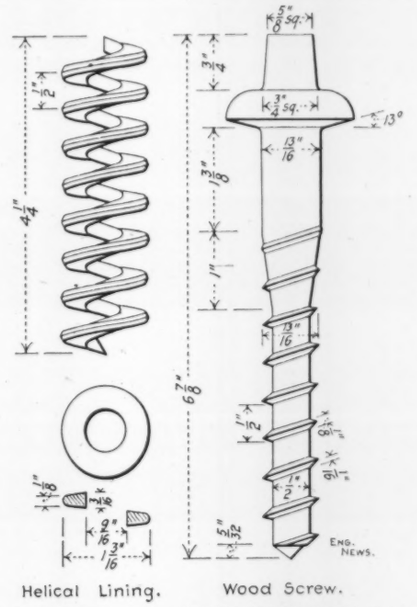
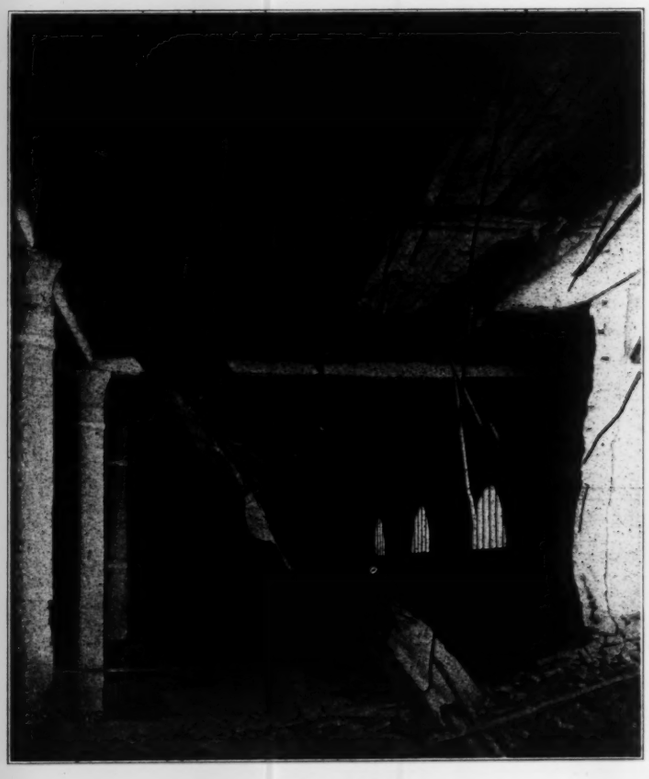


Fig. 1. Screw Spike and Thiollier's Steel Lining for Spike Hole; Pennsylvania Lines.

The spike and spiral lining as used on the Pennsylvania Lines are shown in Fig. 1, while Fig. 2 shows the relative positions of the parts in the tie. Fig. 3 shows the arrangement of spike and tie-plate used in the experiment on the Pennsylvania Lines, and it will be noted that the tie-plate has a flat base, with no claws or ribs to cut into the tie and render the plate self-attaching. This is in accordance with general European experience, the screw spikes being relied upon to hold the rail and plate rigidly to the tie, which cannot be done with the ordinary



INTERIOR VIEW.

EXTERIOR VIEW.

VIEWS SHOWING BOX GIRDER SUPPORTS TORN FROM A REINFORCED CONCRETE FLOOR SLAB BY THE CALIFORNIA EARTHQUAKE, LEAVING THE SLAB IN PLACE.

drive spike. On the other hand, the top of the plate has a rib or shoulder to resist the outward thrust of the rail base, thus relieving the spikes of this duty and reducing the wear or "necking" of the outer spikes. Heretofore, tie-plates with flat top surfaces have been most generally favored by American railways. The tie-plates are 15-32-in. thick and the intermediate plates are 9¼ × 6 ins.; the joint plates are 11 × 6 ins., to allow for the flanges of the angle splice bars, which are slotted to receive the spikes, as shown. The holes are 29-32-in. diameter for the ¾-in. necks of the spikes. The track is laid with 100-lb. rails of the Am. Soc. C. E. section, spliced with 33-in. six-bolt angle bars.

The Thiollier system of rail fastenings is in use on a number of railways in Europe, and pulling tests made with screw spikes at the shops of the Paris, Lyons & Mediterranean Ry. (France) gave the following results: Screw spikes in pine ties, 3,300 lbs.; in hollow hardwood dowels screwed into the pine ties, 9,900 lbs.; in pine ties with bored holes fitted with the Thiollier lining, 13,200 lbs. The lining can be inserted at the tie-treating plant, or it can be inserted by the section men on the track, a special tool being provided to screw it home. One of the advantages claimed for this system is that it can be applied to old ties in which common spikes have been used. The old rough hole is bored and tapped, and the spiral lining inserted, giving a good hold for the new screw spike. The system is adaptable also for wood screws in building construction and for attachments to concrete work, telegraph poles, etc., and is used for this latter purpose by the French State Telegraph Department.

In our issue of Aug. 25, 1904, we illustrated some of the forms of screw spikes used by European railways, and that of the French Eastern Ry. is now being manufactured in this country by the Oliver Iron & Steel Co., of Pittsburg, Pa., but it has not yet been applied in railway service. The spike is of the general design shown in Fig. 1, but is 5⅜-ins. long under the head, 15/16-in. diameter in the neck and 23/32-in. in the shank. The thread has a ½-in. pitch and a diameter of 15/16 ins. Other firms are also manufacturing screw spikes for experimental work.

Wooden tie-plates have been extensively and successfully used on railways in France for a number of years, and experiments made in this country are giving very satisfactory results. Their object is to prevent the disintegration and cutting of the wood of the tie by the rail, and while this has been effectively obtained by the steel tie-plates so largely used by American railways, the wooden plate is of course very much cheaper. The Northern Pacific Railway., the St. Louis & San Francisco Ry., and the Atchison, Topeka & Santa Fe Ry. are all using wooden plates, and while their use is experimental they have been applied on stretches of 40 to 50 miles of track. The woods so far used for this purpose are red cypress, red gum, white oak and beech;

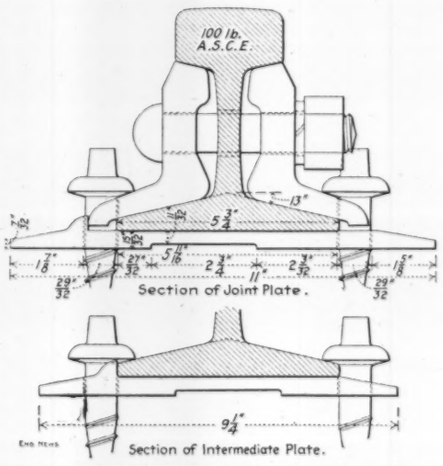


Fig. 3. Experimental Track Construction with Screw Spikes and Flat Steel Tie-Plates; Pennsylvania Lines.

some of them are creosoted, but this is not considered necessary with hard woods. The plates are ⅜ to ¼-in. thick, with a length equal to the width of tie, and a width equal to that of the rail base. The grain of the wood is lengthwise of the rail.

The Cleveland, Cincinnati, Chicago & St. Louis Ry. is now putting in 100,000 creosoted beech tie-plates, weighing about 0.4 lb. each, and costing 0.6 ct. each (including the creosoting). These plates were made and creosoted by the Columbia

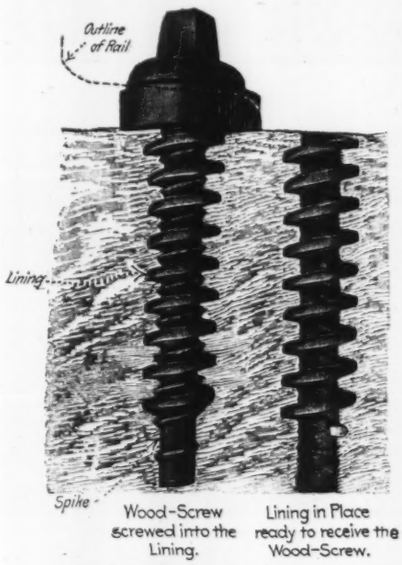


Fig. 2. The Thiollier System of Rail Fastening.

Creosoting Co., of Shirley, Ind. The Gulf, Colorado & Santa Fe Ry. has had wooden tie-plates in use for about a year on 50 miles of track. They wear slightly and occasionally split, but not to any considerable extent. They do not tend to cause the rails to creep. Mr. F. G. Pettibone, General Superintendent, states that he considers them preferable to steel tie-plates on roads of medium heavy traffic and equipment, for the reason that the first cost is cheaper and the cost of application is nominal. These wooden tie-plates can be placed in track for 1 ct. per plate, or 2 cts. per tie. The plates which this road has been using are made of cypress and birch. An examination was recently made of those which have been in track a year, and while they were found to have worn slightly, they were considered good for at least two years' life. Some difficulty was experienced at first by reason of the plates slipping endwise from under the rails, and the practice was therefore adopted of driving two small nails in the corners of the plate.

In a report on ties and rail fastenings, by Mr. Hermann Von Schrenk, U. S. Department of Agriculture, it is stated that the wooden tie-plates used on the Eastern Ry. of France are of hard wood, 8 ins. long, 5 ins. wide (the width of rail base) and ¼-in. thick. The ties have seats trimmed to receive the plates, which are held by the pressure of the screw spikes, but this cutting of a recessed seat does not seem at all advisable or necessary. The plates cost about $2 per 1,000 and last from 1 to 1½ years in main track. When worn out, the spikes are slackened, the old plate is pushed out, a new one inserted and the spikes again screwed home.

In regard to the cutting of rail seats on ties, as noted above, tie-spotting machines are very frequently used abroad (in connection with tie-boring machines) to face the seats of hewed ties to an even bearing and to a level bearing or with the proper inclination, since in Europe the rails are usually set with the webs inclined inward. Similar machines have also been used to a small extent in this country, and it is proposed to install them as part of the equipment of the new creosoting plant of the Atchison, Topeka & Santa Fe Ry., of Somerville, Tex., which was described in our issue of May 3, 1906.

THE EFFECT OF COPPER IN STEEL is summarized by Mr. F. H. Wigham in a paper, which was a report of research work carried out by him, read before the Iron and Steel Institute, as follows:

(1) Copper is very difficult to alloy with steel so as to obtain a homogeneous mass containing over 2% even with the addition of aluminum.

(2) Steel alloyed with copper in the pure form with the addition of aluminum is not so perfectly mixed as it is when it is added to the charge of steel in the furnace, and more copper could safely be employed provided it was in the metal before it was completely converted into steel.

(3) In steel containing 0.5% or more of carbon it is not of practical value to use more than 0.6% of copper.

(4) The steel with 0.25% of copper and alloys up to 0.25% of copper with high carbon (say, of 0.70%) give, with or without a high percentage of manganese, a good quality of wire.

In conclusion, it may be considered as proved that copper to the extent of 0.25% is no disadvantage in the manufacture of the best classes of steel wire.

In the course of making this research no less than 20 tons of cuprous steel were manufactured in the open hearth furnace, the materials used being the purest available.

A TRIAL SPEED OF 19.33 KNOTS was made by the U. S. battleship "Georgia" at the acceptance trial on June 14. This is the highest speed ever attained by a battleship in the United States Navy.

A NEW METHOD OF CALCULATING BRIDGE STRESSES UNDER WHEEL LOADS.

(With two-page plate.)

An interesting new method for the computation of stresses in truss bridges under wheel loads was described quite fully by Mr. W. T. Curtis in a paper presented recently before the Western Society of Engineers at Chicago, Ill. The method combines rapidity and convenience with a high degree of simplicity. It bases on the use of a specially-computed table, called End-Shear Table, for the specific type of wheel loading in question. A part of such a table was given in the paper in question, being condensed from the full-size table computed for Cooper's E-50 loading by Mr. Josiah Gibson, C. E., of Milwaukee, Wis., who originated the method. Through the courtesy of Mr. Gibson we are enabled to reproduce the complete table on the double-page inset sheet in this issue. The following description of the construction and use of the table is taken largely form Mr. Curtis' paper.

The table gives directly the end shear at either abutment of any span from 6 ft. to 300 ft. long, for any position of the double-headed E-50 train. The *maximum* end-shears (left-hand or right-hand end) for each span are given a distinctive mark, so that they may be found and read off from the table without further labor. Similarly, a distinctive mark is used to single out the maximum "pier-reactions" for each length of span; that is, the live-load reaction on a pier between two spans of equal length. An auxiliary table enables the pier-reaction for adjoining spans of unequal length to be found with little additional labor.

The end shears and pier-reactions are utilized for the computation of bending-moments in simple manner, by virtue of the following:

PROPOSITION.—The moment at any point in a span is equal to the moment produced at that point by applying at the same point an imaginary load equal to the pier-reaction of two imaginary spans joining at the point in question, and having lengths equal to the right and left-hand portions of the actual span.

It follows that the moment is a maximum when the pier-reaction of the two imaginary spans is a maximum. As this is given directly by the table, the *position* for maximum moment at any point of a span is obtained directly from the table, and the process of finding the value of the maximum moment is reduced to finding the moment due to a single concentrated load, the amount of this load being taken from the table.

PROOF: Suppose a beam of span l be loaded with concentrated wheel-loads as follows:

On the left-hand portion of the span:

P_1 at distance a from *left* abutment.

P_2 at distance b from *left* abutment.

etc., etc.

At the point where the moment is to be found:
W at distance y from left abutment and distance x from right abutment, x + y being equal to l.
On the right-hand portion of the span:
Q_1 at distance m from *right* abutment.
Q_2 at distance n from *right* abutment.
etc., etc.

The problem is to find the criterion for maximum moment, and the value of this moment, at the point W, distant y from left abutment and x from right abutment.

The left abutment reaction of the entire span is:

$$R_1 = \frac{P_1(l-a) + P_2(l-b) + \ldots + Wx + Q_1 m + Q_2 n + \ldots}{l}$$

The bending moment at W then is:

$$M = R_1 y - P_1(y-a) - P_2(y-b) - \ldots$$

$$= \left[P_1(l-a)\frac{y}{l} + P_2(l-b)\frac{y}{l} + \ldots - P_1(y-a) - P_2(y-b) - \ldots + W\frac{xy}{l} + (Q_1 m + Q_2 n + \ldots)\frac{y}{l}\right]$$

Noting that $l - y = x$, this reduces to

$$M = (P_1 a + P_2 b + \ldots)\frac{x}{l} + W\frac{xy}{l} + (Q_1 m + Q_2 n + \ldots)\frac{y}{l}$$

$$= \left[\frac{P_1 a + P_2 b + \ldots}{y} + W + \frac{Q_1 m + Q_2 n + \ldots}{x}\right]\frac{xy}{l}$$

Putting F for the expression in brackets,

$$M = F\frac{xy}{l}$$

which evidently is equal to the moment produced at the point by a single concentrated load F acting at that point.

This equivalent concentrated load F will be seen to be made up of three parts,

$A = \frac{P_1 a + P_2 b + \ldots}{y}$ = right-hand reaction of a span of length y, loaded the same as the left-hand portion of the actual span l.

W = load at point y, x, where the equivalent load F is applied.

$B = \frac{Q_1 m + Q_2 n + \ldots}{x}$ = left-hand reaction of a span of length x, loaded the same as the right-hand portion of the actual span l.

These quantities have the same meanings as the values A_Y, B_X, and W in the table. Their sum F is, therefore, the pier-reaction for two spans y and x, and it will be clear that M for a given point in a span is maximum when the pier-reaction F is a maximum, which gives the desired criterion for maximum moment.

The procedure for finding the maximum moment at a given point of a span, by the use of the above proposition, is as follows: Find (from the table) the position of loads which will give the maximum pier-concentration for two adjoining spans of lengths equal respectively to the left and right-hand portions of the actual span, and read from the table the value of this maximum pier-concentration; compute the bending moment at the point in question in the actual span, when a load equal to this maximum pier-concentration is placed over the point.

DESCRIPTION OF THE TABLE.

The wheel-diagram is given at the head of the diagram, with wheel-spacings and wheel-loads noted directly below. (The loads given are in pounds for each rail.) Under each wheel are two columns of figures, A and B, which have the following meanings: For any specified span, as listed in the first column (headed L), the figure in Column A gives the *right-hand* end-shear produced by the engine when the wheel at the head of the column is over the *right-hand* end of the span; the shear given does *not* include the wheel at the head of the column.

Column B gives the *left-hand* end-shear produced by the engine when the wheel at the head of the column is over the *left-hand* end of the span; the shear given does *not* include the wheel at the head of the column.

MAXIMUM END SHEAR (and ABUTMENT REACTION).—The shears occurring simultaneously with the maximum abutment reactions, are indicated by a heavy line immediately over the figures. This maximum shear occurs when the wheel at the head of the vertical column is placed at the point of support. This feature gives a direct reading of maximum end-shear.

The abutment reaction is found by adding the wheel load at the point of support to the end shear. The greatest abutment reaction, therefore, occurs when we have the greatest shear, and the table is thus direct-reading for both.

In girders without panels the end-shear is the same for all practical purposes as the abutment reaction, for when the wheel producing this reaction is moved slightly off the abutment towards the center of the span, the shear is only slightly less than the original abutment reaction, decreasing in amount from this abutment-reaction as the distance of the wheel from the abutment becomes greater.

MAXIMUM PIER REACTION.—The pier-reactions for two equal spans of length L each, are found by adding together shears A and B in the column under the wheel on the pier, and adding the weight of this wheel as given at the head of the column. The wheel giving maximum concentration or maximum pier reaction for two equal spans each of length L, that is giving maximum value of A + B + Wheel-load, is designated by a circle between the figures for A and B; thus, wheel 3 gives maximum pier-reaction for two equal spans for all lengths of span from 6 ft. to 17 ft, wheel 12 for two spans of 40 to 42 ft. length each.

According to the proposition which was given above, these positions of loading will give the maximum moment at the corresponding point of a single span equal to the combined spans. That is, wheel 12 gives maximum center moment in a span 80 to 84 ft. long; in an 80-ft. span the equivalent center load, equal to the pier reaction of two 40-ft. spans, would be (wheel 12) 48.2 + 25.0 + 61.8 = 135,000 lbs., and the maximum live-load center moment would be

$$135.0\,\frac{40 \times 40}{80} = 2{,}700 \text{ thousands of pound-feet.}$$

The table is direct reading for maximum center-pier reaction in this manner for spans up to 150 ft. in length; but for spans of greater length the maximum pier reaction, as indicated by the circled shears, does not occur until a portion of the uniform load has crossed the pier. The little auxiliary column under the uniform load, commencing at the line for 144-ft. span, indicates just what portion of the uniform load must cross the pier in order to produce a maximum pier reaction for two equal spans of length indicated at the left-hand margin. The figures in column A indicate, as before, the right-hand shears. Inasmuch as the pier is now under the uniform load, there is no wheel load to consider, as is indicated by the 0, 0 at top of the column for W. The reactions are, therefore, the same as the shears, and the pier-reaction is found by adding the two shears A and B for the span in question.

For example, consider the pier reaction caused by two equal spans each 160 ft. long. We find the maximum when 18 ft. of the uniform load has passed the center of the pier, and the amount of the reaction of the pier is 229.7 plus 200.0 (with no wheel-load to add), making a total of 429.7 thousands of pounds.

For spans of unequal length, the pier reactions under any wheel may be found by adding together Shear A for one span and Shear B under the same wheel for the other span, together with the weight of the wheel at the point. The *maximum* pier reaction for spans of unequal length is found under the wheel indicated in the auxiliary table provided for this purpose. This is Table II, at the right below the main table, and is labeled "Wheel which gives Maximum Concentration." Span lengths are indicated in horizontal line across top of table, and in vertical column down the side, and the number found at the intersection of the lines for any two spans gives the wheel which will cause maximum pier reaction when placed directly over the pier common to the two spans considered. Thus, a pier supporting spans 60 and 120 ft. long will give a maximum reaction when wheel 9 is over the pier, and this number 9, not being overlined in the auxiliary table, indicates that the shorter span is ahead, followed by the longer, [this relative location being necessary on account of the fact that the locomotives are assumed to be always traveling from right to left]. Knowing the position of the loads, we now simply have to read the main table for the following, and sum the results.

Right-hand shear A for the 60-ft. span (wheel 9) ..... = 88.4
Left-hand shear B for the 120-ft span (wheel 9) ..... = 167.3
Weight of wheel 9 ..... = 16.25

Giving as a maximum concentration 271.95

The maximum moment at the point 60 ft. from one end in a 180-ft. span will also occur when wheel 9 is over this point, the train coming on from the side of the 120-ft. portion; this maximum moment is:

$$271.95 \times \frac{120 \times 60}{180} = 10{,}878.0 \text{ thousands pound-feet.}$$

INTERMEDIATE SHEARS.—The operation for finding intermediate shears is simple, although the formulas (given below the table) appear somewhat involved. The operation consists of (1) dividing the span, as before, into two imaginary spans at the point considered, and finding from the table the left-hand reaction of the right-hand imaginary span [B_R + W]; (2) multiplying this imaginary load by the distance [x] to the right abutment and dividing by the span length; (3) [if there are wheels to the left of the point considered] finding their reaction on the right abutment of the full span, and subtracting this from the result of (2). If there are no loads to the left of the point considered, then the result of (2) is the desired shear. In the form of a formula this is, using the notation previously employed in demonstrating the value of maximum moment:

$$\text{Shear} = \frac{[B_R + W]\,x - P_1 z - P_2 y}{\text{span}}$$

where P_1 and P_2 are the wheels to the left of the point considered, these wheels being distant from z and y from the left abutment.

The preceding formula holds only for girder spans. For trusses with open panels the shear is greater than obtained from the formula by the amount of the right-hand stringer-reaction of the loads in the panel directly to the left of the point considered, which may be read from the table. The procedure for trusses is simplified by the auxiliary table for C at the left of the upper portion of the main table. This sub-table gives, for panels 8 to 50 ft. long, the left-hand stringer-reaction for a stringer of L length when the wheel noted at top of column is over the right-hand end of stringer (train moving toward left). In this case the following formula is used, the point in question being distant y=L from the right-hand abutment and $x = z + L'$ from the left-hand abutment, and the panel in front of the point being L' in length:

$$\text{Shear} = \frac{(B_L + A_{L'} + W)\,L - CL'z}{\text{Span}}$$

No simple criterion is afforded for locating the wheel which gives maximum shear. The Eddy load-summation diagram may be used for this purpose, or, as maximum shear will be given by one of the first two or three wheels, comparison computations are quickly made.

Thus, suppose it is required to find the maximum shear at the second panel-point from the left, in a 144-ft. span having six panels of 24 ft. each, under E-50 loading:

Try Wheel 2.

$$\text{Shear} = [(B_{96} + A_{24} + W)\,96 - C_{24}\,24)] \div 144$$
$$= [(156 + 8.3 + 25.)\,96 - 4.2 \times 24] \div 144$$
$$= 189.3 \times \frac{96}{144} - 4.2 \times \frac{24}{144}$$
$$= 126.2 - 0.7 = 125.5$$

Try Wheel 3.

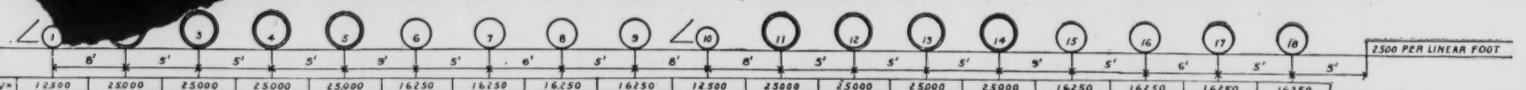
$$\text{Shear} = [(147.6 + 25.5 + 25.)\,96 - 12. \times 24] \div 144$$
$$= 132.1 - 2.0 = 130.1$$

The maximum shear therefore occurs when wheel 3 is over the panel-point, and amounts to 130.1 thousands pound-feet.

END SHEAR TABL… …gines" followed by a Uniform Train Load of 5,000 lbs. per Lineal Foot of Track. Cooper's E-50 Loading

Josiah Gibson, C. E., M. West. Soc. E., Milwaukee Wis.

(Table gives End Shears for One Rail, in Thousands of Pounds.)



VALUE OF C						W=	12500	25000	25000	25000	25000	16250	16250	16250	16250	12500	25000	25000	25000	25000	16250	16250	16250	16250
						L	B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B	A B
						6		42	42 ○ 42	42 ○ 42	42	27	27	27	27		42	42 ○ 42	42 ○ 42	42	27	27	27	27
7	6	5	4	3	2	7		77	71 ○ 71	71 ○ 71	71	46	46 23	23 46	46		77	71 ○ 71	71 ○ 71	71	46	46 23	23 46	46 23
					125	8		94	54 ○ 54	54 ○ 54	54	61	61 41	41 61	61		94	54 ○ 54	54 ○ 54	54	61	61 41	41 61	61 41
					111	9	28	14 111	111 ○ 111	111 ○ 111	111	72	72 54	54 72	72 14	18 28	14 111	111 ○ 111	111 ○ 111	111	72	72 54	54 72	72 22
					100	10	50	25 125	125 ○ 125	125 ○ 125	125	81	81 65	65 81	81 25	33 50	25 125	125 ○ 125	125 ○ 125	125	81	81 65	65 81	81 31
					91	11	68	34 139	136 ○ 139	139 ○ 136	136	89	89 74	74 89	89 34	44 68	34 139	136 ○ 139	139 ○ 136	136	89	89 74	74 90	89 41
					83	12	85	42 188	146 ○ 188	188 ○ 146	188	95	95 95	95 95	108 42	54 83	42 188	146 ○ 188	188 ○ 146	188	95	95 95	95 99	108 51
				221	77	13	96	48 217	154 ○ 212	212 ○ 154	212	50	77 125	100 113	113 100	125 46	63 96	46 212	154 ○ 212	212 ○ 154	212	50	77 125	100 113	113 109	125 61
				205	71	14	125	54 232	170 ○ 232	232 161	232	58	89 139	104 128	128 113	139 54	81 125	54 232	170 ○ 232	232	161	232	58	89 139	104 128	128 113	139	2
				152	67	15	150	58 280	183 ○ 250	250 178	250	76	117 152	125 141	141 125	152 58	98 150	58 250	183 ○ 250	250	178	250	76	117 152	125 141	141 129	152	8
				180	62	16	172	63 281	195 ○ 266	266 192	281	91	141 165	143 152	152 135	163 63	112 172	63 281	195 ○ 266	266	192	281	91	141 165	143 152	152 140	165	5
				169	59	17	181	66 309	206 ○ 279	279 205	309	105	162 182	159 163	163 144	182 81	124 191	76 309	206 ○ 279	279	205	309	105	162 182	159 163	163 151	162	18
			338	160	56	18	208	69 333	215 292	292 ○ 217	333	117	181 199	173 172	172 152	199 97	135 208	88 333	215 292	292 ○ 217	333	117	181 199	175 174	172 162	159	18
			316	151	53	19	237	72 365	224 303	309 ○ 227	365	128	197 214	186 180	180 159	214 112	145 237	98 365	224 303	309 ○ 227	350	128	197 214	186 186	180 173	214	18
			300	144	50	20	263	75 375	231 321	325 ○ 244	375	138	225 228	203 193	187 166	228 125	163 263	108 373	231 321	325 ○ 244	375	138	225 226	209 197	187 184	228	14
			286	137	48	21	286	77 353	238 331	339 ○ 260	353	185	250 240	231 205	205 171	240 137	178 286	116 353	238 331	339 ○ 260	353	155	250 240	231 208	205 196	240	19
			273	131	45	22	307	80 403	244 352	352 ○ 274	403	170	273 251	251 216	222 188	251 159	192 307	131 403	252 352	352 ○ 274	403	170	273 252	251 220	222 207	251	16
		451	261	125	43	23	326	82 424	250 365	364 ○ 288	424	184	293 261	268 227	238 203	261 178	205 326	145 424	264 365	364 ○ 288	424	184	295 264	268 232	238 219	261	17
		432	258	126	42	24	356	85 438	255 378	375 ○ 299	445	196	313 271	285 256	252 217	271 198	217 364	158 438	276 378	375 ○ 299	443	196	313 276	285 243	262 231	271	18
		415	240	115	40	25	380	85 457	260 396	385 ○ 311	440	208	340 285	310 245	265 230	280 215	236 380	170 457	286 396	385 ○ 311	460	208	340 288	310 255	265 243	280	20
		399	231	111	38	26	404	87 474	269 412	394 ○ 327	476	225	365 237	333 252	286 242	297 231	250 484	188 474	256 412	394 ○ 327	476	225	365 300	333 267	286 254	297	21
		384	222	107	37	27	426	88 490	269 427	403 342	457	241	389 309	355 260	306 262	313 255	265 426	120 490	311 427	403 342	491	241	389 312	355 279	306 266	313	22
		371	214	103	36	28		446 89 503	272 442	411 386	504	256	411 320	375 275	325 281	329 277	279 446	205 503	325 442	422 ○ 356	504	255	411 324	375 291	325 298	329	23
		358	207	99	34	29	466	91 515	276 455	418 369	511	269	431 330	393 290	342 298	343 297	291 466	219 515	336 455	435 ○ 369	517	269	431 336	393 303	342 290	345	24
		346	200	96	33	30		483 92 536	279 467	425 382	529	282	450 359	419 309	358 315	356 317	303 483	233 536	350 467	447 ○ 382	529	282	450 348	419 315	358 502	386	26
		335	194	93	32	31		500 93 555	282 484	431 398	540	294	468 348	443 317	381 330	376 335	315 500	248 555	361 484	458 ○ 398	540	294	468 360	443 327	381 314	376	27
	641	324	187	90	31	32		516 94 571	285 580	438 414	551	305	484 356	465 329	403 352	395 359	325 516	266 571	331 500	473 ○ 414	556	306	484 372	465 339	403 326	395	28
	621	314	182	87	30	33		535 95 587	288 514	443 429	561	315	504 372	486 347	423 373	413 383	335 535	272 587	386 514	488 ○ 429	570	319	504 384	486 351	423 338	413	29
	683	305	176	85	29	34		554 96 601	290 528	449 443	570	329	522 386	506 365	442 392	430 404	351 ○ 554	287 601	400 428	501 ○ 443	584	331	522 397	506 363	442 350	430	30
	586	296	171	82	29	35	51.1	96 613	293 541	459 456	579	341	539 400	525 382	460 411	446 425	367 571	301 613	414 541	514 ○ 456	587	343	539 409	525 375	460 363	446	32
	569	288	167	80	28	36		588 97 632	295 558	458 468	587	353	556 413	543 358	484 428	468 444	382 588	314 632	426 558	526 ○ 468	609	356	556 421	543 387	484 375	468	33
728	554	280	162	78	27	37		603 98 648	297 574	463 480	595	365	571 425	559 415	507 451	489 463	386 603	326 648	438 574	538 ○ 481	625	368	571 433	559 399	507 387	469	34
709	539	273	158	76	26	38		622 99 664	299 589	467 491	602	376	584 443	579 433	529 473	509 480	409 622	338 664	451 589	553 ○ 494	640	380	586 446	579 412	529 399	509	35
691	526	266	154	74	26	39		640 99 675	301 606	471 504	609	386	599 460	597 453	549 496	527 457	428 640	349 675	468 604	567 ○ 506	655	393	599 458	597 424	549 411	527	36
673	512	259	150	72	25	40		657 100 693	303 618	475 518	619	396	613 476	614 472	568 516	545 513	446 657	360 693	482 ○ 618	581 ○ 519	668	405	613 470	614 436	568 423	545	36
657	500	253	146	70	24	41		673 101 710	305 630	479 530	622	405	625 492	630 489	587 533	568 531	463 673	370 710	495 ○ 631	594 ○ 532	681	417	629 483	630 448	587 436	568	36
641	488	247	143	68	24	42		689 101 726	307 643	482 542	628	420	637 507	646 506	604 551	590 549	480 689	386 726	508 ○ 644	606 544	684	430	645 495	646 460	604 448	530	40
626	477	241	140	67	23	43		704 102 742	308 655	485 553	634	434	648 526	661 528	621 568	611 567	495 704	401 742	520 657	622 ○ 557	709	442	660 507	661 472	621 460	611	40
612	466	236	136	65	23	44		722 102 757	310 669	489 564	639	447	659 545	675 545	640 586	631 583	516 722	415 757	531 670	636 ○ 570	724	455	674 520	675 485	640 472	631	43
595	456	231	133	64	22	45		739 103 771	311 682	492 574	644	460	669 564	689 569	658 600	650 599	536 739	428 771	542 684	651 ○ 582	738	467	688 532	689 497	658 485	650	44
586	446	226	130	62	22	46		755 103 785	313 695	495 584	649	472	679 581	702 586	675 618	668 617	554 755	441 785	553 687	664 ○ 595	752	479	704 544	705 510	675 497	668	45
573	436	221	128	61	21	47		770 104 798	314 707	497 598	654	483	689 598	714 607	692 636	685 635	572 770	459 799	568 710	677 ○ 607	765	492	720 557	721 522	692 509	685	46
561	427	216	125	60	21	48		785 104 810	315 719	500 613	659	506	698 619	726 624	708 655	702 652	590 785	476 815	583 723	690 ○ 620	781	504	735 569	736 534	708 522	702	48
550	418	212	122	59	20	49		803 105 825	316 731	503 626	663	521	707 639	738 641	723 669	721 668	611 803	492 827	597 736	702 ○ 633	796	517	750 581	751 546	723 534	721	49
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Engineering News was the first of American engineering journals to urge the importance of the independent motor car as a means for the economical handling of light traffic. We recorded four years ago the early work in this country with steam motor cars and have followed from time to time the developments in this class of service on English and Continental railways. More recently still we have recorded the current development of various types of gasoline and gasoline-electric motor cars in this country.

We give space in this issue to a valuable paper by a Western engineer, Mr. F. W. Hild, discussing the economic field for this new system of transportation, and bespeak for it the careful attention of our readers. It is undoubtedly true that the promoters of some of these new independent motor cars have been disposed to claim for them everything in sight. In the popular press, if not in the technical journals, these cars have been heralded as competitors of the electric railway and the steam locomotive. The main purport of Mr. Hild's paper is to show that these independent motor cars are not properly to be considered as competitors at all. Their field is separate and distinct from the field in which the electric railway, with its cars taking current from a central power station, has shown its supremacy. Moreover, they are hardly to be considered as competitors of the steam locomotive even. Where they displace the steam locomotive, it is because the work to be done is of a sort to which the locomotive is ill adapted.

As Mr. Hild says, the motor car is adapted for light traffic, and for light traffic only; and we may add that a disregard of this fact by the designers and promoters of motor cars is leading to mistakes which are very likely to give an undeserved black eye to the whole motor-car business. Most of the motor cars now being experimented with appear to us to be too heavy, too complicated and too heavily powered to adapt them for their real field of work.

What that field is, also appears to be strangely overlooked; both here and abroad experiments are being made with motor cars on suburban and interurban lines, of fairly heavy traffic. So far as we can see, the motor car has small chance of success in any such location. The place where the motor car—or the properly designed motor car—can save money and earn money is out in the backwoods. There is a very large mileage of railways in this country, on which the regular passenger traffic is small and is bound to remain small for long years to come, no matter what facilities for travel are offered. On these branches and spurs, old locomotives discharged from main line service are wheezing out the remnant of their days, hauling infrequent passenger trains which most of the time do not earn enough in fares to pay the train crew's wages. The management conduct their business in this manner because nothing better is open to them; but we know from frequent inquiries sent to this journal that the poor economy of the locomotive for such service is fully realized by many intelligent and progressive railway officials, and that a potential demand exists for a more economical type of motor, and will be felt whenever such a motor is made available.

As to whether any of the various gasoline or gasoline-electric combinations now being exploited are adapted to meet this demand, we must express our very grave doubts. We have said that the field for the motor car is out in the backwoods; but a traveling electric power station on wheels out in the backwoods is likely to go wrong inconveniently often and leave its load of passengers stranded a long way from anywhere. We are sceptical on the whole, as to whether the gasoline motor in any form is adapted for such service as that under consideration. There is probably no better reason for the prevalent fad of gasoline-electric cars than the current popularity of the gasoline automobile. As Mr. Hild points out, however, a breakdown on a private vehicle is a mere trifle compared with a similar breakdown on a railway line rendering public service.

There is good reason to believe that for the field where the independent motor car is really economical, i. e., the backwoods, a steam car should be superior to anything of the gasoline type, and from that point of view the motor cars of half a dozen years ago were better designs than those now being exploited. We are well aware of the defects of those early steam cars. Their designers made the mistake that is now being repeated by the gasoline car designers of making a car too big and heavy and putting too much power in it—in other words, sacrificing too much to the matter of speed. In our opinion, high speed is the least desirable feature of a motor car. Out in the backwoods, maximum speeds of 15 to 25 miles an hour are quite high enough, and are higher than are now reached by the present equipment in many instances. By adopting moderate speeds it becomes possible to use smaller motors and still have equal power to ascend steep grades or haul a trailer. Smaller motor means lighter weight, less wear and tear of track and better adaptation to the light rails and bridges of branch lines. Smaller motors mean also smoother riding cars.

We have before expressed the opinion that the design of such an independent steam motor car should offer no very serious mechanical difficulties. If American locomotive builders had as much initiative and originality as the American builders of electric machinery, we should probably have seen some progress in this direction. As it is, the really progressive work in motor car design appears to be done in Europe.

By a vote of 110 to 36, the House of Representatives on June 15 adopted an amendment to the Sundry Civil Appropriation bill providing that no part of the appropriation of $25,000,000 for the coming year's work on the Panama Canal should be expended for a sea-level canal. The principal speech in favor of the amendment was made by Congressman Burton, of Ohio, well known to engineers by his long service as Chairman of the House Committee on Rivers and Harbors and universally recognized as one of the ablest legislators at the National Capitol.

In the Senate, a vote is to be taken on the Kittredge bill for a sea-level canal on Thursday, June 21, and it is alleged that a majority in its favor is likely to be obtained in that body. Whether this deadlock between the two houses (if it occurs) will be broken by the yielding of one or the other, or whether the whole matter will be postponed to be again taken up at the short session opening next December remains to be seen.

We noted in our issue of March 8 that one of our technical contemporaries had taken up cudgels for the sea-level plan with more zeal than discretion. In its issue of June 9 we are pained to note that this same contemporary throws discretion to the four winds. It accuses the four Senators on the committee who favor a lock canal of misrepresentation in the following language:

> The general tone [of the minority report] impresses one on its first reading as expressing almost frenzied fear lest the sea-level plan be adopted. It is in striking contrast to the judicial character of the committee report.* The exaggerations of statements of facts are often so excessive that they become actual misrepresentations.

Let us see who is guilty of misrepresentation. We take as a sample of our contemporary's argument what it has to say on conditions at the Gatun dam site and quote again from it as follows:

> The attitude of the minority toward the physical facts disclosed by the investigations on the Isthmus and their bearing upon the necessary works is illustrated by their treatment of the question of percolation through the subsurface material at the proposed Gatun dam site. The report states that the "rock sometimes called indurated clay . . . comes within twenty or thirty feet of the surface at every part of the dam, except at two places . . ." Immediately following is the statement, "At the narrow bottom of each depression . . . however, some 200 feet down, is sand and gravel, porous and water-bearing."
>
> It would be difficult to write a more grotesque distortion of the actual facts. At the location considered, there are two deep geological valleys filled with porous materials shown by the borings to be freely water-bearing at practically all depths greater than thirty-two feet below the surface.

We wish to draw a contrast between this statement that these gorges at the Gatun dam site are filled below the 32-ft. level with "porous materials, freely water-bearing," and the following excerpt from the record of the borings made at Gatun under direction of Mr. F. B. Maltby, M. Am. Soc. C. E.

The following is a list of bore holes taken in the two geological valleys, showing the depths bored, with remarks as to water flow:

Number of Bore Hole.		Depth of Bottom of Hole Below Sea Level.	Remarks.
16	+86	−103	No water is reported to have flowed from pipe at any depth.
19	+15	−204	No water is reported to have flowed from pipe at any depth.
20	+81	−190	At −32 feet, water flowed over top of casing and continued to −62 feet. Also flowed at −170 feet over top of casing.
22	+40	−173	No water reported until a depth of −124 feet was reached, when water flowed over top of casing.
23	+37	−180	No water reported until a depth of −72 feet was reached, when water flowed over top of casing.
27	+30	−182	No water reported until a depth of −151 feet was reached, when water flowed over top of casing and continued to flow to −170 feet.
29	+75	− 62	No water flowed from pipe at any depth.
31	+50	− 53	No water flowed from pipe at any depth.
32	+92	− 57	No water flowed from pipe at any depth.
50	+58	−116	No water flowed from pipe at any depth.
52	+67	−218	At −41 feet, water flowed over top of casing and continued to flow to −65 feet. At −201 feet, water flowed over top of casing and continued to flow to −214 feet.
54	+51	−260	No water reported until depth of −192 feet was reached, when water flowed over top of casing and continued to flow to −229 feet.
56	+48	−197	No water reported until depth of −118 feet was reached, when water flowed slightly and continued to flow to −131 feet.

This official record of borings shows that of the 13 bore holes, water did not flow at all from 6. From 4 others it flowed only when depths of 118 to 192 ft. were reached, and from 3 only did water appear at depths of 32 ft., 41 ft. and 72 ft. respectively. We leave it to our readers to judge whether our contemporary or the Senators it criticises have presented the more accurate statement of the conditions at the Gatun dam site.

In another editorial in the same issue, our contemporary charges that the Government is con-

*The "committee" report, as our contemporary terms it, was signed by five Senators, while the "minority" report was signed by four!

ducting a "press bureau" to influence public opinion in favor of the lock canal, and says:

> This would not be a matter to be discussed here were it not for the attempt to control from Washington public opinion on technical subjects. We have seen great industries attacked unfairly on the strength of reports which were sensationally written and so incorrect as to be ludicrous to those who know the facts. . . . . We are now seeing an inexplicable attempt to spread abroad through the newspapers statements concerning the Panama Canal that have little or no basis in fact. As one by one the claims made by former advocates of a high-level canal are demolished by the data accumulated at the Isthmus by Mr. Stevens and in other ways, new points of support for that enterprise have to be hunted up, until the affair, as handled from Washington, has ceased to be a rational discussion of an important public engineering problem.

If this means anything, it means that the Panama Canal Commission has been conducting a "publicity bureau" to mislead the public respecting the canal type question. Speaking from intimate knowledge, we can say that the official documents favoring the sea-level plan have been furnished to us as freely as those favoring the lock canal. The sole foundation for our contemporary's charge that we can find, is that when Secretary Taft, Chairman Shonts and other members of the Canal Commission have made public addresses on the canal work, copies of these addresses have been given to the press. If this is a high crime and misdemeanor, our contemporary is welcome to make the most of it.

We cannot leave this subject, however, without adverting to our contemporary's reference to "the claims made by former advocates of a high level canal demolished by the data accumulated at the Isthmus by Mr. Stevens."

So far as we have learned, the data accumulated by Mr. Stevens have been thoroughly effective in demolishing the claims made by the lock-canal opponents. A notable instance was the site for the Gatun locks. As recorded in our issue of April 5, after the sea-level advocates had "discovered" that there was not room enough for a flight of three 900 ft. locks at Gatun, Mr. Stevens made over 100 borings on the lock site which showed ample room for locks 1,150 ft. long desired, with "conditions ideal for construction and permanency," to quote his own words.

Another very recent example of the way Chief Engineer Stevens is "demolishing claims" is the matter of land damages for the 100 square miles and more to be overflowed by Lake Gatun. This is a matter on which our contemporary has particularly harped. As we noted in our issue of March 8, it estimated the cost of these marsh lands on the lower Chagres at the very nice sum of $250 to $1,000 per acre, basing the estimate on the cost of some land taken by the Commission in Panama City. Regarding this matter, Mr. Stevens made the following statement before the House Committee on June 5:

> The argument has been made in many places that the cost would be millions of dollars for this land. That argument is based on the fact that the Commission condemned some land in Panama for which they paid $41,000; ergo, the cost of the land in the interior that they require would be the same per unit. The land which was condemned lies between Ancón Hill and the city of Panama. Panama is on an island, surrounded on three sides by water, and on the other side by the manglares, that is a marsh covered at high tide. Those lands always belonged to Panama, and their right was transferred to us.
>
> Now, the city of Panama is solidly built, and there is hardly room for another house in the town proper, and there is no possible way for Panama to expand, excepting into the sea or a very small way into this manglare, or onto the Santa Rosa tract. In other words, this tract, which the Government acquired and paid $41,000 for, covers two-thirds of all the available area that there is left for Panama to expand in, and Panama is built solidly up to it, which means that it is high-priced business or residence property. Now, it is just as fair to assume that land on Pennsylvania Ave. should be compared as a unit of price with the poorest kind of land you could find over in Maryland or Virginia; in other words, if I go out on Pennsylvania avenue and pay $80,000 for one-third of an acre, that I should pay $80,000 or $90,000 for the same amount of unimproved farm land out in Maryland or in Virginia. This land which would be overflowed for the purpose of the canal is a jungle.

It is by exaggerating the estimated cost of a lock canal in such matters as the damages to overflowed lands that the sea-level party attempt to overcome the great difference between the two plans with respect to cost.

THE DEVELOPMENT AND PRESENT STATUS OF THE COMPOUND LOCOMOTIVE IN THE UNITED STATES.

The compound locomotive appears to have lost favor in this country within the past few years, and this is by no means balanced by the somewhat sudden accession to favor of the four-cylinder balanced compound. The use of the compound locomotive has been mainly in heavy freight service, and when employed in passenger service it has been principally for hauling heavy express trains making comparatively few stops, as the compound does not show to advantage with light trains making frequent stops either in passenger or freight service.

The history of the compound locomotive in the United States covers a period of less than 20 years, as American engineers prior to 1890 gave it but little attention in spite of the extensive experiments and practical use on European railways. The year 1889 marked, in fact, the beginning of its history in this country, and that year was a notable one in the history of American locomotive engineering generally, as no less than three important steps were taken toward the introduction of the compound locomotive. In the first place, the Pennsylvania R. R. in 1889 imported from England a Webb three-cylinder compound built by the London & Northwestern Ry.; this was a passenger engine of the 2-4-0 class, intended for high speeds with light trains. In 1889, Mr. S. M. Vauclain, Superintendent of the Baldwin Locomotive Works, patented his four-cylinder two-crank compound locomotive in which two cylinders on each side were placed one above the other and had their piston rods attached to a singe crosshead. The first Vauclain compound was a passenger engine of the 4-4-0 class built in the same year for the Baltimore & Ohio R. R. In 1889, also, the late Mr. A. J. Pitkin, of the Schenectady Locomotive Works, designed a two-cylinder system of compounding, which was first applied to one of a number of ten-wheel (4-6-0) passenger engines for fast and heavy trains on Michigan Central Ry. Various modifications of the two-cylinder compound system were afterwards introduced by different builders.

In 1902, the Baldwin Locomotive Works built the first four-cylinder tandem compound in this country; this was a decapod (2-10-0-) freight engine for heavy mountain service on the Atchison, Topeka & Santa Fe Ry. In the same year also they built the first four-cylinder balanced compound for regular railway service, although the Shaw and Strong experimental engines had preceded it, as noted in an editorial on "Four-Cylinder Balanced Compound Locomotives" in our issue of March 31, 1904. The Baldwin engine was a ten-wheel (4-6-0) passenger engine for the Plant Lines. It has been followed by several other designs of the same type, and this class of compound is now being used on a number of leading railways, being specially adapted for high-speed service with heavy trains.

Although a number of four-cylinder balanced simple engines have been built in Europe, none have been tried in this country, with the exception of a curious English engine exhibited at Chicago in 1893 and operated experimentally (with unsatisfactory results) on the Chicago, Milwaukee & St. Paul Ry. Some years ago, however, a few three-cylinder balanced simple engines were in use here. No three-cylinder compounds have been built in this country, and the English engine of the Pennsylvania R. R. already mentioned, is the only one that has been operated here. The first four-cylinder duplex compound (having two cylinders carried by the main frames and two by a swiveling steam truck) was built in 1904 by the American Locomotive Co. for the Baltimore & Ohio Ry.; a few others have since been built, but the necessity for the use of this arrangement is, of course, limited.

The great wave of popularity of the compound locomotive in this country began soon after the introduction of the Vauclain four-cylinder two-crank compound, and certainly no other type of compound has ever achieved such a degree of popularity as this. By January, 1892 (or in less than three years), 103 had been built and 53 were under construction. The total number has increased to 1,778 in 1899 and 2,870 in 1903. Many of these engines were for foreign railways, and the great majority of them were for freight service. In 1900, Mr. Vauclain stated that of some 1,200 locomotives then being built or under contract by the Baldwin Locomotive Works about 500 (or nearly 50%) were compounds. Of late years, however, there has been a marked decrease in the orders for these engines. The orders for two-cylinder compounds have also decreased, but not to the same extent, and in fact these latter engines have not been used nearly so extensively as the four-cylinder two-crank engines with superimposed cylinders. The use of four-cylinder tandem compounds is limited to a very few roads.

We are able to give some recent figures of the output of the two companies building the great majority of locomotives for American railways as follows:

The engines built by the Baldwin Works during the period from Jan. 1, 1901, to June 1, 1906, may be classified as follows: simple or single expansion engines, 7,649; Vauclain four-cylinder two-crank compounds, 1,172; four-cylinder balanced compounds, 194; four-cylinder tandem compounds, 137; Mallet four-cylinder duplex engines, 6; two-cylinder compound engines, 42.

During the two years 1904 and 1905, the American Locomotive Co. built 108 two-cylinder compounds and 31 four-cylinder balanced compounds. A comparison of the general locomotive building statistics for the same two years, as given in the table below, shows a rather remarkable falling off in the use of the compound, as already mentioned. The figures for 1905 include 51 four-cylinder tandem engines, leaving only about 30 Vauclain four-cylinder compounds. Practically all the two-cylinder engines are for freight service.

	1904.	1905.
No. of locomotives ordered	2,538	6,265
No. of compounds ordered	211	170
Percentage of compounds	8.4%	2.7%
No. of roads ordering compounds	15	15
No. of roads ordering 10 or more comps.	6	6
No. of compounds for each road	1 to 50	1 to 75
No. of balanced compounds	70	64
No. of two-cylinder compounds	111	24

What are the reasons for this rapid decline in the orders for compound locomotives? A specific objection which has frequently been made against the Vauclain four-cylinder arrangement (with two superimposed cylinders connected to one crosshead) is that owing to the different diameters of and pressures in the two cylinders, there are unbalanced forces exerted upon the top and bottom arms of the crosshead, resulting in uneven strains on the guide bars and "pounding" of the machinery from the crossheads to the driving boxes. These conditions are avoidable by proper design and construction, and with proper maintenance, but under conditions of rough service and hasty roundhouse repair work they are liable to occur, and undoubtedly do occur in many individual cases.

The principal reason, however, lies probably in the unsatisfactory results which have attended the use of compound locomotives when put into service under conditions for which they were not adapted. There is no doubt that in many cases they have been introduced where the conditions were favorable to simple engines, but where the compounds were introduced under the impression that they must of necessity give a better and more economical performance.

The actual fuel economy of compound locomotives, run in service to which they are suited seems to have been proved beyond dispute by extended experience in actual service for long periods of time, as well as by special tests. This was shown very clearly in the report of the locomotive tests made at the St. Louis Exhibition in 1904, an abstract of which was published in our issue of Feb. 15, 1906. For freight engines in ordinary service it appears that an average saving of 20 to 25% over the fuel consumption of simple engines may reasonably be expected; higher percentages are on record, but in many of these cases there is a probability of unduly low effi-

ciency on the part of the simple engine. The Grand Trunk Ry. has used two-cylinder compound engines almost exclusively for freight service for some years, and tests made last year in comparison with simple engines showed a saving of about 26% in fuel. The same result has been obtained in comparative tests on the Northern Pacific Ry. On the Atchison, Topeka & Santa Fe Ry. a six-months test of compounds in freight service showed an economy of 19.3%, while a two-months test in passenger service showed 12.6%. In 1899, the late Mr. J. N. Barr, then Superintendent of Motive Power of the Chicago, Milwaukee & St. Paul Ry., stated that compounds showed an economy of 17% in fuel and 14% in repairs, as compared with simple engines of the same class on the same division and in similar work; while at the same time the compounds were making 7% more mileage.

There are, of course, many instances where the results have been less favorable. Thus it is stated that on the Chicago, Burlington & Quincy Ry. the experience with compounds has been that in freight service the saving in fuel is about offset by extra cost of repairs (to which we shall refer later), and that the simple engine is on the whole more efficient; in passenger service, on that road, however, the results with the compound were more satisfactory.

The weight of evidence certainly indicates a material saving for the compound, and in view of the results obtained in stationary practice there is no reason why this should not be the case. In the locomotive, the higher evaporation and general superiority in fuel economy are due in part to the more thorough combustion of fuel resulting from the more even and constant draft on the fire, as compared with the sharper and intermittent draft of a simple engine; this is indicated by a lower temperature of the smokebox gases. An elaborate report on compound locomotives was made by a committee of the American Railway Master-Mechanics Association in 1900, and among its conclusions were the following: 1, the average saving of the compound in coal consumption is 16.5 per cent., the ton-mile system forming the basis of comparison; 2, the cost of maintaining the machinery may be a little more, but there is no necessity for the compound remaining out of service for repairs any longer than the simple engine; 3, the cost of boiler repairs may average 19.6 per cent. less; 4, the cost of lubrication is about 15 per cent. greater. The following figures are summarized from that report:

	Fuel saving by compound.	Repairs per engine-mile— Compound.	Simple.
Freight (5 roads):			
Max.	25.00%	6.09 cts.	7.29 cts.
Min.	9.00%	1.68 cts.	1.25 cts.
Ave.	17.62%	3.93 cts.	3.79 cts.
Passenger (1 road).	13.80%	2.41 cts.	1.99 cts.

In the St. Louis tests, above mentioned, the steam consumption per indicated-HP. per hour ranged from 23.8 to 29 lbs. for the simple engines, and from 18.6 to 27 lbs. in the compounds using saturated steam, while in a compound using superheated steam the consumption was as low as 16.6 lbs. The coal consumption per dynamometer-HP. per hour was from 3.5 to 4.5 lbs. for the simple engines, and from 2 to 3.7 lbs. for the compounds; all these were for low speeds, but even at high speeds the latter showed an economy, although the advantages of the compound diminish with an increase of speed. Independent of the question of economy, however, the reserve capacity of the compound when working temporarily as a simple engine gives the compound locomotive a great advantage from an operating point of view.

The superheating system seems likely to become a competitor of the compounding system, although some engineers (both in this country and abroad) favor the use of both systems in combination. On the Canadian Pacific Ry. the use of compounding has become firmly established for freight service, owing to the high cost of fuel, but some of the superheater engines already show a higher economy than the compounds.

Summarizing the whole situation, it must be apparent, we believe, to any unprejudiced observer, that the compound locomotive is here to stay, and that its use is likely to increase in all classes of service for which it is adapted. That it is not adapted to service where it is underloaded or where great variations exist in the loading, or where extremely high speed is called for, is pretty well known to every one familiar with the elementary principles of steam engineering. All that compounding—or expansion of steam through two or more cylinders in succession instead of one—can do is to reduce the loss due to condensation and re-evaporation that occurs through the change in temperature which accompanies the expansion of steam. In an engine running at very high speed, internal losses in the cylinder are less than at low speeds, so there is less opportunity for compounding to effect a saving. In an engine running under variable loads, and up and down hill, the compound with its larger cylinders and pistons and more complicated steam passages is likely to consume more power merely to keep itself running than the simple engine. Probably the most fruitful source of failure in compounds, however, is failure to keep the steam valves tight. Every engineer of large practical experience with steam machinery realizes that one of the greatest sources of waste in nearly every class of steam engines of the slide valve type is leaky main valves. This is particularly true of locomotives, hoisting engines and the like which are apt to operate with worse water than stationary plants and suffer worse from scale and eroding matter in the valve passages. While simple locomotives also suffer from leaky valves, the more complicated steam passages in the compound locomotive and the more general use of large piston valves furnish greater chances for steam leaks, and consequent loss.

LETTERS TO THE EDITOR.

A Suggestion for Procedure in Transit Work.

Sir: The writer has found the following method very satisfactory in azimuth surveys:

Having leveled up the instrument, bring the vernier to zero. With the lower motion set off the magnetic bearing of a true south line (equal numerically to the declination of the needle). On the upper motion then set off the back azimuth. If there is no local attraction and the work has been correctly done, the rear rod will be nearly bisected. Accurate bisection should be made with the lower motion. This method has the following advantages: (a) the needle check is obtained before it is forgotten and before side shots are taken; (b) no bearings need to be computed; (c) in woods or other partially obstructed sights the back station is oriented upon with minimum effort.

Yours truly,

Charles A. Holden.

Thayer School of Engineering, Hanover, N. H., June 7, 1906.

Filling Behring Straits.

Sir: From the editorial remarks on filling in Behring Straits in your last number one would infer that the depth of water is much more than stated in my premise. By the later United States charts, the water at the Straits is not over 180 ft. at the deepest point, and will not average over 156 ft., which would require about one-fourth of the material to fill in the Straits that would be necessary if the depth of water were 300 ft. At a rough estimate it would take 300,000,000 cu. yds. of rock at either point—the Straits, or at St. Lawrence Island. The rock can be put in for at most $1 per yd. and likely for much less, and in procuring the rock a great many miles of roadbed could be built on the mainland and islands. This liberal estimate allows for a double-track railway, 30 ft. above sea level.

If H. M. Flagler can build 140 miles of sea wall railway with actually 36 miles in the sea on concrete walls, two strong governments might fill in Behring Straits and warm up the coast and the Aleutian Islands.

Since it has been proven that barley can be made to ripen in 76 days and in latitude 65° north or south, railways must come to eastern Siberia and Alaska for grain, gold, silver, copper and coal.

Yours truly,

R. J. Mershon.

1317 West 105th St., Chicago, Ill., June 11, 1906.

[Why should railways be built thousands of miles to haul traffic which can be carried to market far more cheaply by sea?—Ed.]

Using the Mississippi Flood Water for Rice Irrigation.

Sir: Some years ago a suggestion was made to relieve the lower reaches of the Mississippi River by diverting some of the flood water through the bayous to the west, but there were many objections, one of which was the great cost of regulation. Now, owing to the immense increase in the acreage of rice, the bayous are taxed beyond their flow to supply the rice farmers and the limit of available land has almost been reached.

If a canal were constructed leaving the Mississippi River below the mouth of Red River and crossing the state of Louisiana, making use of the natural waterways as may be advisable and necessary, water could be brought as far as the rice fields of Texas. The cost of such a canal could be borne partly by the government and partly by the state, tolls being charged for water and for the use of the canal by boats.

A large area of land would thus be brought into cultivation which is now uncertain owing to the low water stage in the summer in the bayous when water is most needed for the crop. Yours truly,

Louis G. Hester, C. E.

Houston, Tex., June 13, 1906.

[We do not see how it would be possible to create a gravity canal to carry water from the Mississippi so far to the West. Even if the water in the Mississippi were high enough when in flood to furnish the necessary head to produce a flow, and if the topography were such as to permit the building of such a canal, it is pretty certain that at low water in the Mississippi, water would not enter the canal. Moreover, if we mistake not, low water in the Mississippi usually coincides with the low water period in the Gulf bayous.—Ed.]

Concerning the Right of an Engineer to Have the Best Offer for His Services.

Sir: Any one who follows any branch of the engineering profession has to pay for his education. If self-educated, his payment is made in the form of many sacrifices; if a college man, his education often means an expenditure of several thousand dollars. Under these circumstances, he expects to get a fair return upon his investment, and when opportunities of his bettering his condition present themselves, it is an infringement upon his rights if any one attempts to deprive him of these advantages.

Before any one enters the service of any railroad having terminals in this vicinity, he should think twice before entering the service, for the writer has been informed of a number of cases where these railroads have stood in the way of men bettering themselves.

There have been cases where men employed by a railroad have accepted a situation with another road; the company in whose service they were, finding out where the men were going, have written to the other road asking that the offer be withdrawn, as the services of the men were needed by the road in whose employment they were at that time, and the railroad which has been requested to withdraw the offer has done so.

The writer knows of one case of a young married man with a family dependent on him for support. He was engaged to come to work with one of these railroads, leaving a situation to do so, and when he arrived he was told that, owing to an order having gone forth to cut down expenses, he could not be taken on. Fortunately, he obtained a situation in another department, but he wisely left the service of the road at the first opportunity.

The same road, in considering the raising of salaries, took into consideration whether a man was married and had a family, or if he was single. The principle acted upon was that a man with a family could not as readily throw up his job as a single man; consequently, the salaries of some men with families were kept down.

A young engineer once told the writer that he had made it his rule not to enter the service of a railroad unless he had a "good pull." There is only one time where a man may enter the service of a railroad with impunity, and that is when he has a long bank account. R.

New York, June 11, 1906.

[If the charges above set forth are true, we venture to say that the corporation official responsible for such acts is not only guilty of a mean and dishonorable action, but is actually working against the best interests of the corporation he is supposed to serve. Anyone but a blind man can see that in these times corporations need friends; and if they cannot find friends and supporters and defenders among the bright, competent and clear-headed men in their own service, they are not likely to find them anywhere. Faithful and efficient and loyal service is the key to success in business, and such service is to be secured even more by square dealing and honorable treatment than by the actual size of salaries paid.

No doubt it is annoying and troublesome to have high-class men, who carry large responsibilities, taken away by better offers elsewhere; but the way to remedy that condition is not by a general agreement among corporations that they will not take men from each other's service. Such an agreement is contrary to public policy and wholly indefensible. It is just such illegal and arbitrary acts on the part of our great corporations in the past that has given the labor unions their strength and influence, and taught them to defy the law and override justice.

As regards the charge in paragraph five of our correspondent's letter, we are strongly inclined to doubt it. It is probably true, however, that this corporation and others, too often delay the raising of salaries until they are compelled to do so to prevent men taking positions elsewhere. The fair way of rating salaries is on the basis of what a man's services are worth. If an offer elsewhere would induce you to raise his salary, then do the fair thing and raise it now.

We do not hear much complaint or protest from engineers concerning the application of the law of supply and demand in fixing their compensation, notwithstanding the fact that in past years the profession has had to carry large responsibilities and accept small payment. They are justified in protesting, however, when in times of business activity attempts are made to interfere with the free operation of this law to keep down their salaries.—Ed.]

The Possible Uses for Reinforced Concrete in Earthquake Proof, Fire Resisting Building Construction.

Sir: I have read with interest the editorial comments and the letter by Mr. Hawkesworth, in your issue of May 24, regarding the design of reinforced concrete structures in earthquake countries, and desire to submit the following statements in the discussion: Mr. Hawkesworth is misinformed regarding one point, as evidenced in the following extract from his letter:

We know that the steel skeleton of some of the higher buildings has been left fairly intact, while the shell of stone or brick, which formed the walls, was shaken off.

The writer has examined every building of that description in San Francisco, and in no case, even after the fire, was there any evidence that walls, supported on the steel frame at each floor, had been shaken off. Their behavior in that respect was far better than expected.

The question of clothing the steel frame in concrete is merely adding the walls to that portion which has already been done in concrete, or, in other words, to the floors. In the new Building Code for San Francisco, prepared by the committee, of which the writer was a member, it is proposed to allow the construction of walls of reinforced concrete 6 ins. or more in thickness. The reinforcement must be 1% of the concrete, and must be rigidly fastened to the steel frame. Walls with stone, ashlar or brick facing, may be made with reinforced concrete or plain concrete backing. This Building Code will probably be adopted.

The writer desires to caution Eastern engineers against drawing conclusions from reports regarding steel buildings in San Francisco. There were many kinds, the frame that carried the walls and was wind braced; the frame that carried walls and was not wind braced; the frame that carried floors only and was or was not wind braced, and the buildings that had an interior frame but with part of the floor carried on brick walls. Indiscriminate reference has been made to these buildings as steel structures, without definite knowledge of their construction. There was the widest variation in the behavior of these buildings. It must be recognized that an inspection occupying an hour will tell but little. The buildings must be investigated as to whether they stand vertically or were distorted. The steel must be uncovered to determine if rivetted connections have sheared or not. The construction of the building as to bracing or lack of bracing and of the other points mentioned above must be taken into account. This is not a matter of a day. Many buildings have not been cleaned, as insurance matters have not yet been settled. In others the steel has not been exposed. The tower of the Ferry Depot, a steel frame, carrying a curtain of stone ashlar with brick backing, is a case in point. The stone was broken and joints started. Every one said the steel was in good condition, as the tower was upright; but, when the stone was removed, diagonal rods were found broken, gusset plates torn out and rivets sheared.

A committee of the local association of members of the American Society of Civil Engineers is preparing a report upon buildings and the fire and earthquake damage. The report will cover, in detail, the construction of the buildings and the damage. It is hoped to include nearly all buildings, certainly some of each type, with comments. It must be recognized that such a report can only be issued after complete investigation, and that only after buildings have been cleaned. Hence time is required.

In the matter of reinforced concrete buildings, the proposed Building Law limits their height to 102 ft. This limitation was due solely to earthquake considerations. Many engineers will be inclined to question this, as altogether too conservative. It is argued that since reinforced concrete is susceptible of mathematical analysis, why not place it on the same standing as steel? The answer is this: An earthquake, excepting on lines of fracture, or where there is a slipping of "made" ground, is a succession of waves. In a wave, there is little progression of the particles, the motion being vertical. The resulting effect on a building is a swaying motion, backward and forward. The rupturing of parts occurs when the inertia of the upper portion prevents its taking the motion before something breaks. A tall building becomes like a whip shaken in the hand. Hence there results not tension only, as Mr. Hawkesworth suggests, but tension and compression in columns and shear, which, if the building has diagonal bracing, appears as tension or compression. If the shear is taken care of by portal or knee bracing, there results the usual bending in columns and beams. The stresses that arise are identical with the wind stresses, although their magnitude is unknown. As a proof, one has but to examine the diagonal cracks in brickwork, which appear in nearly every one of the buildings affected. This has resulted in the distortion of several steel frames not provided with wind bracing.

Hence the problem before the concrete designer is one that involves the above. While the literature of the day is filled with discussions of beams and columns, there is little, if any, reference to the stresses in the finished structure, other than those caused by gravity. The steel designer takes care of the wind stresses by knee or portal bracing, and occasionally slips in some diagonals, when the architect is not looking. Any one who has calculated, say a 12-story building to resist wind at 30 lbs. per sq. ft., knows of the relatively enormous stresses in portal or knee bracing on the lower stories. These stresses exist when wind or earthquake shakes the structure. They result in reversed stresses in girders and excessive bending of columns. This Mr. Hawkesworth mentions. How will the reinforced concrete designer transmit the stresses from column to girder, is the question that must be answered. That it is only partially done by the steel designer is admitted, and sometimes never done. In this latter case it will not do to say that the mass of the building takes up the stress. In an earthquake the mass of the building makes matters worse. That this is so, the writer can cite, as proof, a building 150 ft. high, where no wind bracing of any kind was used. This structure is from 7 ins. to 9 ins. out of plumb. Another similar one, 100 ft. high, is 4 ins. out of plumb.

Reinforced concrete stood well in the few examples extant, of which the two buildings at Stanford University are the best. They were relatively low structures, but the evidence is in their favor, although they were not entirely without injury of a minor nature. Those who would design buildings of a height of two or three times the base dimension, must not be misled by the behavior of such low structures, however good it may be. Only by consideration of the stresses mentioned above can a building be said to be properly designed, and some suggestions along that line would be interesting.

As a closing statement, the engineers are again cautioned against hasty conclusions from the preliminary reports being published. It is the opinion here that bad work is responsible for about 90% of the earthquake damage. By bad work, is meant bad designing and bad execution. On every hand there is evidence of an almost total ignorance of the ordinary principles of design, and that generally goes with bad work. The earthquake simply brought this to light. A man who holds a brief for any one kind of material or form of construction can find evidence to support his claim, but the impartial investigator must avoid such. The civil engineers of San Francisco hope to offer some good information in the report mentioned, and only ask their fellow craftsmen to be patient until all the evidence is in.

Yours very truly, J. D. Galloway.

604 Mission St., San Francisco, Cal., June 2, 1906.

Heat in the New York Subway.

Sir: During the agitation relative to the "heat problem" in the New York Subway, I should like to ask, through your columns, why it should not be considered and solved as a problem of ventilation pure and simple. In your issue of June 7 Mr. Rice says the only practical way is "to exhaust the air at points midway between stations, thereby causing the inflow of air through the station openings. By this means the freshest air is always secured at the stations. Such iron dust as may be liberated is also drawn into the interior and out through the exhaust openings there provided," like the system planned and used from the very first on the Boston Subway, which you say has "never been uncomfortably warm." This would entirely remove all chance of repeating the desperate conditions I, for one, endured at the time of the recent fire, when it took me one hour and thirty-five minutes to go on the express train from the Brooklyn Bridge station to 116th St. and Lenox Ave., for Mr. Rice truly says "At the present time there is no provision whatever for renewing the air in case the subway should become filled with smoke," which means no positive ventilation, no change of air, for the passengers, in spite of former published statements circulated a short time ago, entitled "Subway Air, as pure as in your home." How could such conditions for relief be honestly overlooked and omitted from the plans of the New York Subway as now built, when the problem was already met and solved years before in other cities?

Very truly yours, J. Calvin Locke.

748 Marcy Ave., Brooklyn, City of New York, June 16, 1906.

Sir: The exhaustive investigation by the Engineering Staff of the Rapid Transit Commission under Mr. Rice into the heat and ventilation conditions in the New York Subway has provided food for thought to engineers throughout the country. The publication of the report in Engineering News of June 7 and the editorial comment in the issue of June 14 lead one to believe that suggestions from the profession will be acceptable.

The following may be of some value in the solution of the problem of ventilation: It appears that the temperatures in the Murray Hill section of the tunnel are at variance with the general conclusions of the engineers for other portions of the subway. We must therefore look for some peculiar conditions here which exist only in this section. At this point the uptown and downtown travel is diverted into two separate tunnels. This circumstance in itself explains the lower temperatures. All trains in each tunnel of the Murray Hill section traveling in the same direction create a current of air in the direction of travel, which is not neutralized by trains traveling in the opposite direction.

Further investigation will prove that a current of air exists in all parts of the subway where the traffic in opposite directions is carried in independent tunnels. A single train occupying 13½% of the total cross-section occupies 27% of the half cross-section, which would be the result of separating the traffic by partitioning the tunnel. The air compressed by the moving trains forced along the tunnel in the line of least resistance at a high velocity gives a continuous current throughout the length of the tunnel between stations. Outlets for the foul air at the approaches to stations and inlets for fresh air at the stations will insure a thorough ventilation of the midsections and stations. The increased pressure of the air occasioned by the trains moving and stopping intermittently at stations in the contracted cross-section must greatly improve the conditions of exhalation and inhalation beyond the results observed at certain points. The investigations of the subway engineers prove that trains moving in opposite directions in the same tunnel cause simply a local agitation of the air and a neutralization of currents.

The structural conditions of the subway air are most favorable for the separation of the uptown and downtown travel. The expense of filling in the openings formed by the central row of columns is small compared with the cost of installation and maintenance of fans, whether exhaust or supply.

However conditions not realized by the reading public may exist which would make it difficult to carry out the scheme of separation of uptown and downtown traffic in the subway. Yours respectfully,

T. J. MacCarthy,
Assistant City Engineer.

Holyoke, Mass., June 17, 1906.

Sir: I have been much interested in the report of Mr. George S. Rice, Chief Engineer of the Rapid Transit Commission, on the heat conditions in the New York Subway, as published in the June 7 issue of your journal. There is one feature, however, which I think has not received the attention it merits. In paragraph ten of this report, under "Investigations in Detail," we find the following paragraph:

"Three of the ways in which the cooling may be accomplished are: (1) By evaporation of water. (2) By refrigeration. (3) By disposing relatively cold water throughout the subway in such a manner that it will absorb the surplus heat without the water coming in direct contact with the air."

I do not wish to enter into any discussion of the relative merits of the three systems of cooling here suggested. But I do wish to offer some opinions on the first method, viz., cooling by evaporation.

Continuing in the next paragraph, Mr. Rice says:

"Ample cooling effect could be accomplished by evaporation. The only objection to this plan is its *possible* effect toward increasing the humidity in the subway." (Italics mine.)

With this brief comment, Mr. Rice dismisses what I believe to be the only successful solution of the subway cooling problem.

Mr. Rice does not state, or even suggest, in what way it would be possible to apply evaporation to this prob-

lem. In order to make this method in any way adequate, it would be necessary to finely subdivide the water (or other fluid used) which in evaporating would absorb the heat present in the air. It is evident that water is the only fluid which could be economically applied in this case, and the only successful way in which it could be subdivided for rapid evaporation would be by sprinkling or spraying it into the air. The finer the degree of this subdivision, the greater would be the cooling effect.

The scheme which I would suggest—which, however, I do not claim to be original with me—is the injection of cold water in a fine spray at suitable intervals throughout the length of the subway. This injection and spraying could be best secured by the atomizing effect of a fine jet of compressed air, applied in a spray nozzle similar to those which are already used in some phases of the textile industries. The compressed air is already available throughout the entire length of the subway, in the electro-pneumatic switch and signal system. Its use for this cooling system would simply mean running the electrical compressors already installed during longer periods of the day. They are already equipped to maintain a constant pressure automatically. I am not sure that any water mains are at present laid in the subway, but, at any rate, it would be a comparatively small matter to lay them. The application of such a system of cooling, in briefest outline, might be as follows:

A small air and water main of, say, 2-in. pipe could be hung along the steel columns, between the tracks and close to the roof. At intervals of perhaps 100 ft. small laterals of, say, ½-in. pipe could be tapped off from these mains, leading to a spray nozzle supported directly above the middle of each track and discharging downward. The air and water mains could be divided into sections, any one of which might be turned off or on, as the conditions in the adjacent section of the subway demanded. A very small amount of water and a very small volume of compressed air would thus suffice to keep a fine spray sifting down throughout the entire cross-section and length of the subway.

Such a system would have a three-fold cooling effect. First: The expansion of the compressed air on leaving the nozzle would produce a very low temperature. No one can dispute this, as it is in accordance with a well-known law of physics. This cold would be imparted to the water spray, which would be therefore much cooler than the water in the pipes. Furthermore the expansion of this volume of compressed air would in itself have a decided cooling effect on the surrounding atmosphere. Second: The water spray in falling through the air would, by evaporation, absorb the heat in the air, giving probably the maximum cooling effect applied upon all the air which comes in contact with this spray. Third: The water spray settling upon the cars in passing will moisten their outer surfaces and this deposited moisture will be evaporated under the rapid motion of the train, acting to cool the surface material of the cars.

Aside from the cooling effect, this system would have another advantage in settling the iron dust which is said to be in suspension in the air of the subway. Indeed, it would probably largely prevent raising this dust, by keeping all the interior surfaces moistened. And a little superfluous water turned loose in the subway might have a certain very sanitary value in washing out some of the filth which accumulates.

Mr. Rice acknowledges that "the only objection to the evaporation system is its possible effect toward increasing the humidity." I believe that he is mistaken in this statement. Such a system as I have suggested, instead of increasing the humidity, would actually lower it. This is not a theory, but an actual fact which can be verified repeatedly by observing such natural phenomena as we all experience here in New York.

We have all noticed that the summer days which are most intolerable to us are not the hottest days, but the days when the humidity is highest. But if a storm comes, bringing with it a down-pour of rain, this oppressive condition is immediately relieved. This is due to exactly such a process as I have suggested be applied in the subway. The falling rain cools the air, condenses the water vapor, carries it down with the rain and leaves the atmosphere dry. The falling spray in the subway would have exactly this same effect, cooling the air, condensing the water vapor, carrying it down with the falling particles of cold water and leaving the air dry. This seems almost a paradox. But it is well known among pneumatic engineers that one of the most effective methods of drying compressed air is by forcing it through a volume of cold water, the air emerging actually dryer than when it entered the water.

Mr. Rice himself, who is a mining and tunneling expert of long experience, will agree with me that the coolest mines and tunnels he has known are those in which a great deal of water is present, trickling over the walls and falling from the roof. He will also, I think, acknowledge that the air in these mines, far from being humid, was decidedly dry, crisp and bracing. Is there any reason to suppose that a refinement of Nature's own methods would not work just as satisfactorily in the New York Subway?

The only possible difficulty which, as it seems to me, might be urged against this system, would arise in the disposal of the water which would fall to the floor of the subway. But this is a difficulty which may be easily exaggerated in anticipation. In the first place, this scheme would require very little water. In the second place, this small amount of water could easily be disposed of by the drainage system which is, undoubtedly, already installed in the subway.

The system of cooling by means of water injection with compressed air which I have here briefly sketched is a rational one, based upon well-known physical laws and verified by the experience of the best engineers. While it has never been applied in practice on a scale of such magnitude as would be involved in the cooling of the New York Subway, there can, I think, be not the slightest doubt that it would be effective and, in comparison with the other two methods of cooling suggested in Mr. Rice's report, highly economical in installation and operation.

Very truly yours,

Lucius I. Wightman.

11 Broadway, New York City, June 15, 1906.

[Is not our correspondent reasoning in a circle? He proposes to cool the subway by *evaporation* from a finely divided spray and from the wet surfaces of the cars, the stone ballast, etc. If this evaporation takes place it cannot possibly have any other effect than to increase the humidity of the air, for manifestly all the water evaporated must be taken up by the subway air. It cannot go anywhere else.

He tries to get around this humidity difficulty by suggesting that the cool particles of water would condense the water vapor from the moist air of the subway, and actually leave the humidity lower than before. But if this were actually to occur, this would not be cooling the subway by evaporation, but warming it by condensation. It is, of course, true that as many heat units are given out when water is condensed as are absorbed when water is evaporated. Actually then, the only cooling done by the system proposed (supposing it to work as Mr. Wightman thinks it would) would be the heat absorbed to warm the water up to the subway temperature, plus the trifling refrigerating effect due to the expansion of compressed air.

If there were an abundance of *cold* water available along the line of the subway, it might be practicable to cool and at the same time dry the subway air by the system proposed by Mr. Wightman; but it must be remembered that we are dealing not with a moderate amount of heat, but with millions of heat units. Croton water, in the quantity which would be required for such a purpose as suggested, could not possibly be spared; and it is doubtful if it would be cool enough. Water from the rivers is too foul and is also warm in the summer. It is very doubtful whether sufficient deep well water could be obtained to serve the purpose.

As a final word it may be said that the coolest mines and tunnels are not necessarily those in which a great deal of water is present. Nor is the air in wet mines and tunnels necessarily dry. It all depends on whether the water and the rocks are cold or warm. In the former case the air will be cool and dry; but if the rock is warm and the water encountered is warm, as in the Comstock lode and the Simplon tunnel, the temperature and humidity often approach the limit of human endurance.—Ed.]

THE RECLAMATION SERVICE is finding difficulty in retaining its force of engineers on account of the active demand for engineers for railway construction and other large works in the West. About 40 engineers have resigned from the service during the year and a similar number have requested furloughs, usually to take positions with railroad and other organizations. The situation is giving the Department much concern.

RECENT EXPERIENCE WITH COMPOUND LOCOMOTIVES.

Comparative tests of simple and compound locomotives were made recently on the Chicago, Milwaukee & St. Paul Railway by four students of the University of Wisconsin,* and the results were presented at a meeting of the Western Railway Club.

The tests in question were made with a view to determining the relative efficiency of a Vauclain four-cylinder two-crank compound and a simple locomotive of the same dimensions under the ordinary conditions of freight service. The compound engine was built by the Baldwin Locomotive Works and the simple engine was built at the railway company's shops. Both of the engines were of the ten-wheel (4-6-0) class, with the following principal dimensions:

	Simple.	Compound.
Driving wheels	5 ft. 9 ins.	5 ft. 8ins.
Weight on drivers	141,080 lbs.	135,555 lbs.
Weight of engine	182,780 lbs.	178,900 lbs.
Cylinders, HP.	(2) 21 × 30 ins.	(2) 15 × 30 ins.
Cylinders, L. p.		(2) 25 × 30 ins.
Heating surface	2,966 sq. ft.	2,946 sq. ft.
Grate area	34 sq. ft.	35 sq. ft.

The tests were made on the division between Chicago and Savanna, Ill., 138 miles. The freight service on this division is unusually fast. Three regular tests were made with each engine, and a summary of these is given in the accompanying table.

In the discussion on these tests at the Western Railway Club meeting some important facts were developed respecting experience with compound locomotives and their adaptation to different classes of service. We have abstracted this discussion, as follows:

COMPARISON OF RESULTS OF TESTS OF SIMPLE AND COMPOUND LOCOMOTIVES: C., M. & ST. P. RY.

	Simple			Compound		
No. of test	1	2	3	1	2	3
Weight of train, tons	982	1,140	1,152	1,074	1,006	1,050
Running time	4 h. 26 mins.	5 h. 29 mins.	4 h. 17 mins.	4 h. 43 mins.	6 h. 13 mins.	4 h. 22 mins
Speed, miles per hr.	28.20	23.56	29.1	26.5	20.5	28.5
Average dyn. HP.	972	712	633	702	675	821
Average ind. HP.	1,068	779	775	813	753	902
Engine efficiency, per cent.	9.975	8.285	7.75	9.17	10.30	9.73
Engine and boiler efficiency, per cent.	4.80	4.27	3.64	4.74	5.04	4.96
Dry coal, per dyn. HP., per hour, lbs.	4.07	4.41	5.63	4.45	4.10	4.09
Dry steam, per dyn. HP., per hour, lbs.	23.54	28.24	31.80	28.01	25.68	25.50
Water evaporation from and at 212° per lb. of dry coal, fired	6.02	6.44	5.84	6.75	6.76	6.49

Mr. A. E. Manchester (C., M. & St. P. Ry.).—The results obtained by the simple and compound engines in freight service on the particular piece of road referred to have been more than borne out by an 18 months' comparative record kept for each individual simple and each individual compound engine, and for the groups of simple engines and compounds.

At the time the test in question was made there were 11 of the simple engines and 21 or 22 compounds in freight service on the division. In 14 months of comparative record the 11 simple engines had made a better average coal performance than the 21 compound engines. In other words, the simple engines had shown a less cost of coal than did the compound engines, showing that so far as this particular piece of road and its traffic is concerned the simple engine has proved to be the more economical of the two.

This may sound strange when I say that there is a strong probability that the number of compound engines will be increased upon the Chicago, Milwaukee & St. Paul Ry. The very same type of engine with which this test was made was tried on our La Crosse Division, the traffic on which is very different; it is somewhat slower and the weight of the trains is very much heavier than on the division where the test was made. The economies effected by the compound engine as compared with this same type of simple engine ranged anywhere from 18% to 35%, and this was demonstrated regularly, all the time when the comparison is made in the service of that division. Our experience, which I believe is largely borne out by this test, is that we have some divisions especially adapted to the use of simple engines, and other divisions especially adapted to the use of compound engines. The proper thing for us to do is to determine which class of engines is best adapted for service on each of the divisions.

The compound engine is one in which the stitch in time is a great factor. It is not a good engine to turn loose and let go to destruction. It is not a good engine to undertake to keep in repair from your main shops. Any railway that does not maintain a thorough and efficient roundhouse organization had better keep entirely out of the way of compound engines, because the compound engine requires prompt attention, and it is not a wise

*Harold S. MacMillan, Carl S. Reed, Wm. S. Wheeler and Arthur H. Miller.

proposition to put it off until to-morrow when it does need it. If care is taken and the compound engine kept up, my belief is that there is but a very little difference in the cost of repairs. After the 11 simple engines had been in service 15 or 16 months the records were examined and it was found that they were costing 1½ cts. per mile for repairs. The engines had not, during that time, gone into the shop for general repairs. The compound engines were running at the same time, and the cost of repairs for the first 14 or 15 months that they were in service from the builders' shop was 3½ cts. per mile. I believe if the compound engines had been built by us at our shops at Milwaukee, and the same care used in their construction that was used in the simple engine, that the difference in repairs would not have been ¼ ct. per mile, or 1¼ cts. per mile for the compound engine.

Mr. J. H. De Voy (C., M. & St. P. Ry.).—The records for 12 months show that in fuel consumption the simple engine did slightly better than the compound for eight months, the compound being ahead for four months. The profile is such that there is a considerable portion of the road suitable to drifting; the drawbar pull curve shows that the simple engine was not loaded at any time to more than 75% of its maximum tractive power, and that the speed was fairly fast. A test of these same engines on the La Crosse Division with heavier loads and slower speed showed 20.3% in favor of the compound engine. This is a more level division and the engines were loaded to nearer their full capacity of tractive power; the simple engine loaded at 75% of its maximum tractive power will prove very nearly as economical as the compound loaded in the same way. The compound engine must be worked compound to the full extent of its tractive power. Just as soon as you commence to admit live steam into the low-pressure cylinders you will lose your economy, and just as soon as you commence to drift a compound engine you will also lose your economy.

Mr. C. J. Mellin (American Locomotive Co.).—The result of the test as to economy of the compound is disappointing, and would indicate that there is some way for the steam to leak out to the exhaust passage past the valve, as the gain by the double expansion of the steam should not differ so considerably from that of a cross-compound engine, of which scores of test-reports from various roads, both special tests and duration comparisons for years, under the most varying conditions, show that the saving in fuel seldom falls under 20% but is often over 30%, as compared with similar types of simple engines. These records were established already 10 or 12 years ago. On the Grand Trunk Ry. tests were made in 1905 between a simple mogul (2-6-0) engine and two-cylinder mogul and consolidation (2-8-0) engines. The two compound moguls showed a saving in fuel of more than 26%, and the consolidation (though considerably underloaded) showed nearly 21% saving over the simple mogul engine. The fact that the Grand Trunk Ry. has built and ordered this class of compounds exclusively for all its freight service for the last six years and has 55 engines at present under order speaks more than any discussion in their favor. It may be added that there are not less than 160 cross-compounds at present under construction for various roads in the United States and Canada. With these records at hand it is difficult to see why the result in the present engine is so low, and I cannot but think there must be some leakage, allowing steam to pass the piston valve packing rings, or otherwise escape without performing work.

Mr. A. Lovell (A., T. & S. F. Ry.).—While both the boilers are supposed to carry 200 lbs. working steam pressure, the test sheet shows the average pressure carried by the simple expansion engine to be 204 lbs., against 192 lbs. for the compound engine. The firing, therefore, could not have been done with the same degree of intelligence or with an equal desire to give the compound a show. The temperature of external air on days the compound was tested averaged 33° F., against 49° F. for each day the single-expansion engine was tested. The simple engine also operated against a head wind the average velocity of which was 1.7 miles per hour, while the compound had to work against a head wind with an average velocity of 15.7 miles per hour. Both of these circumstances were highly favorable to the single expansion engine. The results would seem to indicate that even the C., M. & St. P. Ry. finds the compound engine to show a saving of 11% over its own design of single-expansion locomotive.

Comparative tests which were made on the Northern Pacific Ry., with which I am thoroughly familiar, showed a fuel economy of 26% for the compound over the single expansion engines of otherwise the same general design and dimensions. On the Atchison, Topeka & Santa Fe Ry. a number of comparative tests in various kinds of service have been made within the past few years. The most elaborate of these was conducted in freight service for a period of six months, and (considering all items of expense) shows a total economy in favor of the compound over the simple engine of 19.3%. A recent 60-day test in passenger service showed less saving, but even in this case the compound is found to be 12.6% more economical than the single expansion engine.

J. A. Carney (C., B. & Q. Ry.).—Our experience with freight compound engines has been that the saving in fuel was about offset by the extra costs of repairs, and that the simple engine was the more efficient. In passenger service the results have been more satisfactory; we are using Atlantic (4-4-2) engines with cylinder 20 × 26 ins. on simple engines and 15 + 25 × 26 ins. on compound engines; the dimensions of the boilers and other details are almost identical. The theoretical tractive force of the simple engine is slightly greater than the compound engine, but they both handle trains of equal weight equally well, although some engineers claim that the compounds are stronger. There is very little difference in the cost of repairs per mile run; 6.04 cts. per engine-mile for simple and 6.17 cts. for compound engines. The fuel consumption on both classes of engines will run from 10 to 11 lbs. coal per car mile. When a compound engine commences to use more coal than an average trip should consume it is time to go through the valves and cylinders on both sides of the engine, as there is no other way of definitely locating the trouble.

Prof. Storm Bull (University of Wisconsin).—It seems to me that the results of the very large number of comparative tests of compound and simple engines (some of which have been quoted here) show conclusively the advantages of the compound engine. It is also my opinion that the really progressive engineers of both this country and Europe have no hesitation in stating that the compound engine is the locomotive of the future.

Mr. D. Van Alstyne (Northern Pacific Ry.).—This paper emphasizes the fact that a compound engine is not at its best at comparatively high speed with light loads. There has been a good deal said lately about the inability of the big engine to haul its theoretical rating, and there are several reasons for this failure to get the most out of the big engine. The principal reason, perhaps, is the inability of the fireman to maintain steam; in other words, the hauling capacity of the big engine is, to a considerable extent, measured by the firing capacity of the fireman. For the past two or three years, the compound engine has been growing in disrepute and losing favor, and I presume this is chiefly because of its lack of reliability and its failure to realize the expected economy in coal. With reference to reliability it goes without saying that the compound engine is not, and cannot be, on the average as reliable as a simple engine. The exception to this is found where water is very bad, because the boilers of compound engines using bad water are always more reliable than those of simple engines. In so far as repairs go, a compound engine may cost more for maintenance, and may cost less; it depends on the local conditions. It is perhaps reasonable to expect it to cost more on the average, and probably it does; but under conditions of bad water it will frequently be found that compound engines will run lighter in repairs than simple engines, due to the fact that they use less water and the saving is in boiler repairs. With a well designed compound, it seems to me that if any great difference is found between the cost of maintaining the simple and the well-designed compound, it must be due to either neglect or stupidity.

As to fuel, it is probably true (and it has been my experience) that a compound engine will not drift down hill with as little coal as a simple engine does. It is not necessary to say that a compound engine burns just as much coal as a simple engine when standing on a side track, and that is one of the important features in a locomotive's duty. For these reasons, a compound never shows the net economy that might be expected of it, but it is on a hard pull that the compound shows its greatest economy, and can be of most benefit to the fireman in making his work lighter or helping him get more tonnage over the road. Aside from any question of fuel economy, cost of repairs or reliability, the fact that a fireman can come nearer making a heavy compound engine haul its calculated rate than a similar simple engine is sufficient argument for compounding heavy freight engines. I will venture to say that the Mallet compound in mountain helper service on the Baltimore & Ohio Ry. could not possibly be fired to the limit of its capacity by one man if it were a simple engine.

Mr. C. A. Seley (C., R. I. & P. Ry.).—It was the experience on the Chicago, Rock Island & Pacific Ry. some years ago that some compound engines failed to hold their own with simple engines, and it was almost conclusively proved that this was due to the character of the service and the division. After they were removed to another territory they did a great deal better work, and their comparison with simple engines was made very much more favorable. During the past year there were some comparative tests made on this road, and it was found that in slow, heavy service the relative saving of the compound as compared with the simple was twice what it was with the same engine in fast service.

A TURBINE STEAMER is being built by the Wm. Cramp & Sons Ship & Engine Building Co., of Philadelphia, for the New England Navigation Co., to run between New York and Boston, by way of Long Island Sound. It will have Parsons steam turbines of 8,000 HP. driving three screws, the high-pressure turbine driving the middle screw and the low-pressure turbines driving the two wing or side screws.

THE USE OF OXYGEN FOR REMOVING BLAST-FURNACE OBSTRUCTIONS.*

By the Chevalier C. de Schwarz.†

All experienced blast-furnace engineers are acquainted with the great inconvenience, anxiety, and even, in certain circumstances, danger caused by the taphole of a blast-furnace becoming closed up by solid iron, so that it cannot be opened by means of the ordinary appliances without a certain lapse of time. There is the danger of the liquid iron accumulating on the hearth of the blast-furnace and reaching the slag and the blast-tuyeres, thus causing serious disturbances and sometimes explosions. It often becomes necessary to make a new taphole higher up, and to reduce or to stop the blast temporarily, which may result in the formation of scaffolds or other serious inconveniences well known to blast-furnace engineers. The case is still more serious if the blast-tuyeres of the furnace get closed up by solid iron, either partially or entirely, owing to a scaffold dropping suddenly, or from other causes. Should it in such a case be impossible to get a hole through the iron blocking up the tuyeres within a certain time, a new temporary tuyere, at a higher level, must be applied, and even this remedy often does not have the desired effect. There are, in fact, few cases in metallurgical practice where quick and effective measures are of greater importance and more imminently necessary than those mentioned above.

Hitherto the opening of tapholes closed up by solid iron has usually been effected by forcing a hole through the iron by means of a steel bar driven by hand-hammers. If hand methods do not suffice, a heavy "ram," suspended on chains and worked by a dozen men, is employed. However, it sometimes happens that the steel bar snaps off, leaving the broken end in the hole already made, or that the liquid iron cools down in coming out, and solidifies in front of the taphole, thus making matters worse than they were before. Coke and heated blast, as well as petroleum, are sometimes employed for opening a closed-up taphole or tuyere, but these require too long a time to take effect, and, in the case of a tuyere, the latter is, as a rule, utterly destroyed by the operation. A strong electric current of from 400 to 1,000 amperes has also been used for opening tapholes, but this method is similarly open to the objection that it does not work quickly enough, and besides it is very expensive. The application of compressed oxygen in such cases has completely overcome all these difficulties, as a closed taphole or tuyere can be opened in a few minutes, and moreover, the method has the merit of being exceedingly simple and cheap.

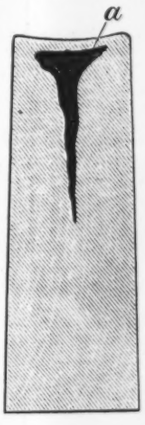
The iron to be burned through (pierced) is first heated from the outside, at the spot selected for making the hole, by means of an oxy-hydrogen flame which, up to now, has proved to be the most useful for the purpose. It can, however, be replaced by any other combustible gas in case of necessity. The hydrogen and the oxygen gas are compressed into two separate steel flasks, each flask being provided with a suitable outlet valve, in order to regulate the pressure and the quantity of the escaping gas according to requirement. The burner consists of an outer and an inner tube, the outer tube supplying the hydrogen, and the inner tube the oxygen. The hydrogen is allowed to escape first, and is lighted, after which the stream of oxygen is turned on. The pressure of both gases is first kept low, but gradually raised and regulated in such a way as to give a very hot flame, which heats the spot upon which it impinges to a white heat. The pressure of the oxygen is then raised to such an extent that the iron commences to burn, which is shown by sparks being thrown about. The pressure of the oxygen is now further raised to 30 atmospheres and above, while the supply of hydrogen is entirely stopped. It is now the iron alone which burns, thus replacing the hydrogen as a combustible, whereby, as shown hereafter, a degree of heat is developed which far surpasses that produced by means of oxy-hydrogen gas. The high pressure of the escaping oxygen, at the same time, serves to force out all the molten iron, thus keeping the hole burnt through perfectly clean throughout the operation. It can be shown that a solid block of cold iron or steel, say 16 ins. thick, can in this way be pierced within one or two minutes.

The heating effect of the oxy-hydrogen flame alone is far too low to serve the purpose of opening closed-up tapholes or tuyeres. This is principally due to the fact that (on account of the comparatively great volume taken up by hydrogen) the loss of heat through derivation is much too large, as compared with iron, taking both, as in our case as combustible matters into account. On burning one kilogram of hydrogen (with oxygen) 13,057 calories are produced, while when burning iron (with oxygen) only 748 calories are generated. However, one kilogram of hydrogen occupies 87,234 times as much space as one kilogram of iron. Therefore a certain volume of iron, when burning with oxygen, produces about 5,000 times as much heat as an equal volume of hydrogen in equal circumstances [(87,234 × 748) ÷13,057 = 4,997]. When iron burns in oxygen the heat evolved is concentrated on a

*A paper read before the Iron and Steel Institute.
†Liege, Belgium.

comparatively small area. This explains the enormously high temperature produced, and the quick action, as mentioned before, notwithstanding that, at the same time, a considerable amount of cold is produced owing to the expansion of the compressed oxygen after leaving the steel flask. This shows itself at the tube leading the oxygen from the flask to the burner, which becomes coated with ice, the temperature of the tube being only about 14° F. The process, above described, yields remarkable results when employed for opening a blast or slag-tuyere blocked up by iron, because the great heat produced when iron burns with oxygen might lead to the conclusion that the tuyere in question must be melted away, taking the thinness of metal in a tuyere into consideration. This, however, is not the case. Experience has shown that, for instance, a slag-tuyere of only 1¾-in. inner diameter can be thoroughly cleaned from all the iron adhering to it without being injured in any way. The tuyere does not get heated at all, but cools down, considering that the temperature of the oxygen, coming from the tube, is, as already stated, reduced below freezing point owing to expansion.

The oxygen process has been successfully applied for opening tapholes of open-hearth furnaces where they have become blocked up with iron or steel. It is of great importance that no delay should occur in tapping an open-hearth furnace as soon as the liquid metal has reached the desired degree of decarbonization, as otherwise its composition might change, owing to the delay, to such an extent as to render it useless for the desired purpose. The new process overcomes difficulties of this nature in a few minutes. Experiments are also being made as to the employment of the new process for improving steel ingots by removing the "pipe" caused in the upper portion owing to shrinkage during cooling. The crust of solid steel or iron above the "pipe" (a) of accompanying figure is burnt through in the way already described, within less than a minute, and superheated liquid metal of the same quality as the rest of the ingot poured in. This thoroughly fills up the "pipe." The experiments are not completed as yet, but the results so far obtained seem to promise final success. This process has also been successfully employed in removing dead-heads or runners on steel castings. This is of special value in cases where the hardness of the steel casting at the place where the dead-head or runner is joined to the casting, is such as to resist the action of the cutting tool. In rolling-mills, where interruptions of work are very costly, the oxygen process can be advantageously employed in melting through and quickly removing any broken shaft or axle-tree from couplings, flywheels, etc., instead of doing this by means of chisels and drills thus causing long delay and expense. The oxygen process has also been used with success for piercing armor-plates for warships and armored turrets. This is of special importance in case such plates are of hard metal. A hole through such a plate of, say, 9-in. thickness, would require two or three hours if drilled in the ordinary way, while with compressed oxygen this work can be done within 15 to 20 seconds. This remark applies also to the manufacture of hollowed weldless steel goods, either pressed or cast, especially if hard steel is used where the driving in of a treblet might spoil the article in question.



While, as already mentioned, oxy-hydrogen has proved the most convenient for producing the necessary initial heat, before applying the oxygen gas alone, in order to open blocked-up tapholes or tuyeres in furnaces, the electric current has proved more convenient for the same purpose if armor-plates, steel castings, etc., are to be pierced. A current of from 4 to 6 volts and 200 to 220 amperes is quite sufficient to produce the necessary initial heat before applying the oxygen.

The oxygen process above described was invented and first practically applied by Dr. E. Menne, engineer to the Cologne Müsener Bergwerks Aktien Verein at Creuzthal in Westphalia. Some improvements have been effected and carried into practical operation by the Societe Anonyme Oxhydrique Internationale at Brussels for cutting boiler plates, tubes, etc., so quickly and accurately that the oxygen process has secured favor as a trustworthy method for this purpose. The arrangement consists essentially of two tubes which can be placed one behind the other, the first tube supplying oxy-hydrogen gas, and the second oxygen gas. The oxy-hydrogen heats the plate up to a white heat, and the compressed oxygen burns (cuts) the plate exactly as desired. The apparatus for guiding the two tubes works in such an easy and exact manner that the slightest pressure of the finger-tips suffices to guide it as desired.

Finally, it may also be permissible to take the financial outlook of the oxygen process into consideration. The principal outlay is that for the oxygen gas, which, at present, costs about 3s. (75 cts.) per 1,000 cu. ft.; but a reduction in this price is expected. For opening a blocked-up taphole or a tuyere, as a rule, not more than 8 or 10 cu. ft. of oxygen are required; in exceptional cases, however, from 20 to 40 cu. ft. of oxygen gas are necessary. The apparatus itself is very simple and inexpensive. It consists of two steel flasks, each with a reducing valve, and of a few yards of iron tubes and armored hose. Several blast-furnace works in England, Germany, Austria, France, and Belgium have already adopted the process, with satisfactory results.

AN EXTENSIBLE BELT CONVEYOR.

The plant of the West Virginia Pulp & Paper Co., at Mechanicsville, N. Y., has recently been equipped with a system of conveying and elevating machinery for handling pulp wood, wood chips and soda ash and lime. The interesting feature of this conveyor system is an extensible conveyor for handling soda ash and lime. The conveyor when extended into a box car (Fig. 1) receives the materials shoveled into the hopper, and, after carrying them to the storage tanks discharges them through a self-reversing tripper. The conveyor runs at an upward inclination of 14½° until it has reached an elevation of 31 ft. above the ground, when a horizontal position is assumed. It is on this horizontal run that the load is discharged by the tripper, the storage tanks being directly beneath. The conveyor is 150 ft. long, and is driven from a pulley on a countershaft at a speed of 300 ft. per min.

The extensible end of this conveyor is shown by Fig. 2. When in its normal position, it allows trains to pass without interference, but when extended it is at the right elevation to enter a box car door, thus bringing the hopper H inside the car. As will be seen from the cut, fixed rolls B are attached to framework C, the movable part consisting of a sliding deck A, which moves on these rolls. The conveyor belt passes over three pulleys, the lower one, D, of which is attached to frame work C, while the other two, E and F, are attached to sliding deck A. In this manner the working of the belt is not affected when the conveyor is extended by block and falls.

This arrangement does away with the use of a track and hopper, which could not be used since the soda ash and lime has to be protected from water. This fact also prevents the use of open, hopper-bottom cars. Box car unloaders could, perhaps, be used to advantage, but the required capacity is such that the expenditure entailed by the installation of such apparatus would not be justified by the saving effected by the doing away with hand labor.

This conveyor system was designed and installed by the Robins Conveying Belt Co., of New York City.

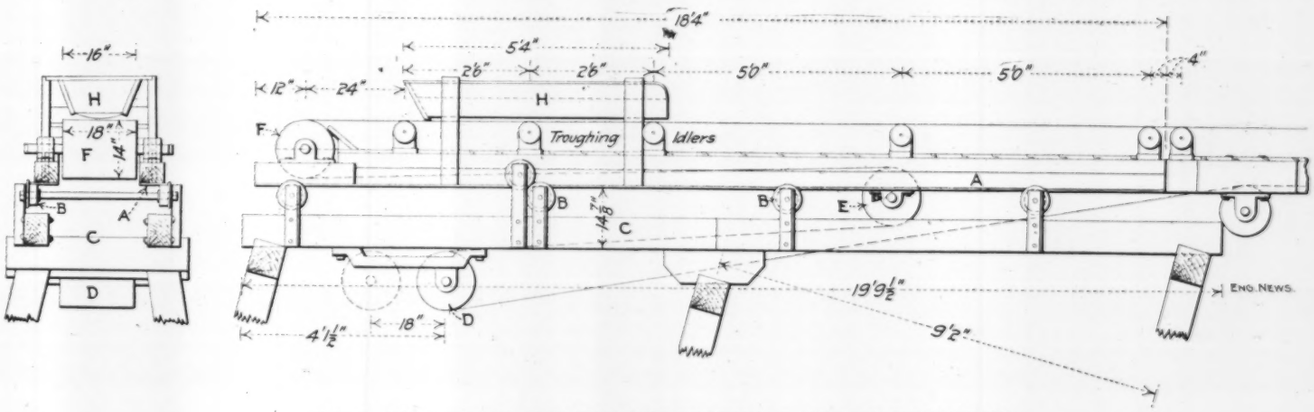


FIG 2. SIDE AND END ELEVATIONS OF EXTENSIBLE 16-IN. BELT CONVEYOR.
Designed by Robins Conveying Belt Co., of New York City.

The MANHATTAN BRIDGE over the East River at New York, N. Y., will be built by the Ryan-Parker Construction Co., of that city, the contract for the steel superstructure having been awarded to them by Commissioner of Bridges Stevenson on June 16. The five bids for the work under the latest plans and specifications were given on p. 529 of our issue of May 10, 1906. This closes a chapter in an unusually tangled history of a large public improvement, the successive stages of which were reported in detail in Engineering News. The contract names the price of $6,493,223, and allows of no

Fig. 1. Extensible 16-In. Belt Conveyor Extended into Box Car.

extras or changes of cost. The contract designs are for a wire-cable suspension bridge with 3¼% nickel-steel stiffening trusses.

THE BATTLESHIP "LOUISIANA" was completed during May, 1906, thereby terminating the race for quickest completion between the "Louisiana" and the "Connecticut," which two vessels were required to be identical in all details. The "Louisiana" was built under contract by the Newport News Shipbuilding & Drydock Co., of Newport News, Va., while the "Connecticut" was built at the New York Navy Yard. The latter vessel was begun two months later than its rival, and since the early part of May no work has been done on it, due to failure of Congress to appropriate money for completing the vessel. On June 1 the "Connecticut" was 97.41% completed; the Navy Department states that about six weeks' work will complete the vessel. The "Louisiana" was completed within contract time, which has been the case in but few of the Navy's shipbuilding contracts in recent years. Several other vessels now building promise to be completed within contract time also; the fact that the work on several of the ships now under construction has been the most rapid on record is attributed in large part to the influence of the rivalry for rapid work between the "Louisiana" and the "Connecticut." At the present rate of construction, the U. S. Navy will, within six months, gain 7 battleships, 4 armored cruisers and 2 protected cruisers.

THE REINFORCED CONCRETE BRIDGE over the St. Joseph River at Jefferson St., South Bend, Ind., is on the Melan system, with four arches of 110 ft. span, elliptical on the intrados, with a thickness of 27 to 30 ins. in the arch rings. The steel ribs have two angles for each chord, with flat lattice bars for the web members, and the chords are 3 ins. from the face of the concrete. The ribs are 35 ins. c. to c., connected by flat bars at intervals of 10 ft.; they were built in sections, and coated with cement grout at the shops. The bridge is 72 ft. wide between spandrel walls, and has a 52-ft. roadway with a double-track electric railway. The concrete was laid in longitudinal sections three ribs wide. A gravel concrete was used; 1 to 5 for the arches, 1 to 8½ for the piers and abutments, and 1 7½ for the spandrel and parapet walls, cornice and balustrade. All exposed faces were given a 1-in. facing of mortar 1 to 2½. The balustrades were molded in cast-iron forms. The bridge is calculated for a live load of 150 lbs. per sq. ft. on roadway and sidewalks, with a concentrated moving load of a 40-ton electric car with 25-ft. wheelbase. The foundations are of piles. The bridge was designed by Mr. A. J. Hammond, City Engineer, and the contract was awarded to Scribner & Heyworth, the work being afterwards taken over by Mr. J. O. Heyworth, of Chicago. The steel work was built by the Wisconsin Bridge & Iron Co., of Milwaukee, Wis. The contract price for the structure was $119,000, exclusive of piling; the piles cost 35 cts. per ft., driven, or $9,377, and the contract for the removal of the old bridge amounted to $7,000, making the total cost $135,377. These particulars are taken from a paper read by Mr. A. J. Hammond before the Western Society of Engineers.

THE PARIS UNDERGROUND ELECTRIC RAILWAY has been completed as far as the first section is concerned, this forming an elliptical belt line with two intersecting lines parallel with its longer diameter. Other extensions are being built, but the traffic is already so heavy that some parts of the present line must be duplicated. The lines in operation in 1905 aggregated about 10½ miles, with an equipment of 360 motor cars and 470 trail cars. During the busy hours of the day the trains are run on a headway of three minutes. The gross receipts for the year 1905 were $5,240,000, and the operating expenses $2,270,700, or 43.44%, as compared with 42.50% for 1904. Of the net profit 60% was paid to the city as interest on the capital expended in construction. The net profit of the Paris Metropolitan Railway Co., therefore, amounted to about $1,288,800. The company has a capital of $15,000,000, and its total expenditure to the end of 1905 was $17,187,700. As the requirements of the line already exceed the capacity of the power station, power is being purchased from electric generating companies. Elevators are to be provided for the comparatively few stations which have the platforms more than 39.36 ft. below the street level, and means are also to be taken for the better elevation of these deep-level stations.

SIDE-DOOR ELECTRIC CARS are being introduced on the interurban lines of the Wilkes-Barre & Hazelton Ry., of Wilkes-Barre, Pa. The car has a middle vestibule 4 ft. 4 ins. wide, with steps the full width and fitted with folding doors. Sliding doors on opposite sides of the vestibule open into the main passenger compartment, 23 ft. long and a special compartment 13 ft. long for the use of coal miners. Each end of the car has a corner compartment for the motorman. The cars were built by the Jewett Car Co., of Newark, Ohio.

PERSONALS.

Mr. Charles S. Bradley, M. Am. Inst. E. E., has been elected to the faculty of the Carnegie Technical Schools, Pittsburg, Pa.

Mr. Ernest McCullough has resumed practice as a consulting civil engineer, making a specialty of reinforced concrete and municipal work. His new office is at 510 Monadnock Block, Chicago.

The following changes have taken place in the Reclamation Service: Messrs. Jos. I. Bingham, Engineering Aid, and A. M. Bouillon, Assistant Engineer, have resigned from the service.

Mr. B. B. Stakemiller, Engineer and Superintendent of the W. D. Boyce Engineering Co., St. Louis, Mo., has resigned and will engage in the engineering and contracting business at Alton, Ill.

Messrs. Clarence Heller and A. T. Wilson have opened offices in the St. Francis Hotel, San Francisco, Cal., as structural engineers, and are at present engaged with the engineering work of Bliss & Favrill, Architects, San Francisco.

Mr. C. J. H. Woodbury, M. Am. Soc. C. E., Assistant Engineer of the American Telephone & Telegraph Co., at Boston, Mass., was honored at the commencement exercises of Union College, June 12, with the Honorary Degree of Doctor of Science.

Mr. A. F. Doyle, formerly the Western Representative of the H. Huennekes Co., has opened offices at 1147-1148 Marquette Building, Chicago, Ill., as Representative of the Standard Brick Machinery Co., of New York City, contractors for the erection of sand-lime brick factories.

Obituary.

M. H. Wright, Assoc. M. Am. Soc. C. E., Assistant Engineer of the Louisville & Nashville R. R., at Atlanta, Ga., died June 8 at Lithia Springs, Ga., where he was spending his vacation.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 21-23. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 29 to July 4. Annual meeting at Ithaca, N. Y. Secy., M. S. Ketchum, University of Colorado, Boulder, Colo.

AMERICAN WATER-WORKS ASSOCIATION.
July 10 to 14, inclusive. Annual meeting at Boston, Mass. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 19 to 20. Semi-annual meeting at Chicago, Ill. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23 to Aug. 4. Joint meeting with the Iron and Steel Institute at London. Secy., R. W. Raymond, New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 15 to 17. Annual convention at New Haven, Conn. Secy., Frank P. Foster, Corning, N. Y.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held at the society's rooms, in Chicago, on June 6, a paper, by Mr. L. E. Ashbaugh, was presented on "The Assessment of Drainage Districts," describing the methods of assessment of property, appraisement of damages, etc. At the meeting on June 13, Mr. A. T. Hammond read a paper on "The Reinforced Concrete Bridge at Jefferson St., South Bend, Ind."

CENTRAL ELECTRIC RAILWAY ASSOCIATION.—At the recent meeting held at Dayton, O., a paper on "Axles for Interurban Cars" was read by Mr. J. R. Replogle, of the Cambria Steel Co. He considered axles made by the Coffin process to be far superior to cold-rol'ed axles, and advocated the following specifications for axles for electric cars:

Carbon, 0.35 to 0.50%; manganese, not over 0.6%; phosphorus, not over 0.05%; sulphur, not over 0.06%; elastic limit, not less than 50% of tensile strength; ultimate strength, not less than 30,000 lbs. per sq. in.; elongation, not less than 20% in 2 ins.; reduction of area, not less than 40%.

The other subjects discussed included trolley-wire fittings, the insurance of the property of electric railway companies, and the handling of freight and baggage.

TECHNOLOGY CLUB OF SYRACUSE.—Members of the club left Syracuse, N. Y., June 15 by special car over the New York Central & Hudson River R. R. for Buffalo, N. Y. on an inspection tour. Upon arrival at Buffalo the party was met by Mr. George W. Pulver, a former member, and, after lunch, the afternoon was spent in inspecting the plant of the Lackawanna Steel Co. Mr. Pulver entertained the club at a six o'clock dinner at the Ellicott Club, after which the evening was spent socially.

Saturday morning the following hydraulic plants were visited: Power-houses Nos. 1 and 2 of the Niagara Falls Power Co. and the plant of the Niagara Falls Hydraulic Mfg. Co. A trip by trolley was then made by the Canadian Gorge Route to Lewistown, where dinner was served. At 1 p. m. a return ride was taken on the American side of the gorge, after which the following plants were visited: Ontario Power Co., Electrical Development Co., Canadian Niagara Co. . After visiting the generating station of the Ontario Power Co., Mr. S. B. Storer, a member of the club and manager of the Niagara, Lockport & Ontario Power Co., entertained the party at dinner. All necessary culinary arrangements were carried on by means of electricity generated at the plant.

The party returned to Syracuse Saturday evening.

STRUCTURAL ASSOCIATION OF SAN FRANCISCO.—A number of engineers, architects, contractors and manufacturers of San Francisco interested in the design and construction of buildings and the manufacture of building materials have formed an association under the name of the Structural Association of San Francisco, for the investigation, study and discussion of the recent earthquake, and fire phenomena and the formulation of conclusions as to the manner in which the best type of building construction should be modified to conform to the observed conditions.

All persons directly concerned in the design, manufacture and use of structural and fire resisting material are eligible to membership, dues being $1 per month. Meetings will be held every Thursday in the Ferry building, at 8 p. m.

The following officers have been elected to serve one year:

President, Prof. C. B. Wing; First Vice-President, Mr. W. J. Miller; Second Vice-President and Chairman of the Executive Committee, Mr. Lewis A. Hicks; Third Vice-President, Prof. Loren E. Hunt; Secretary and Treasurer, Prof. Chas. Derleth, University of California, Berkeley, Cal.

The first regular meeting of the association was held May 31.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.—The regular quarterly meeting of this association was held at Atlantic City, N. J., June 11, 12 and 13, with about 50 members in attendance. The sessions occupied two whole days, with an evening meeting on the first day. Only the third session for the reading of papers was open to the public. At this session there were presented papers on "Cost Reduction of Reinforced Concrete Work," by Mr. E. P. Goodrich; "Etruscan and Roman Mortars as Compared with Modern Concretes," by Mr. R. W. Lesley; "Mercantile Warehouse Construction," by Mr. Ross F. Tucker, and Report of the Research Committee, by Prof. S. B. Newberry.

The paper by Mr. Goodrich has already been referred to in our editorial of last week. It described briefly the methods open to the engineer for reducing the cost of reinforced concrete work, and enlarged particularly upon methods of reducing the cost of form work. As the substance of the argument has already been given in the editorial referred to, there need be no further comment here. In the paper on ancient mortars Mr. Lesley gave analyses and micro-photographs of a number of mortars taken from Etruscan and Roman buildings, and compared them with similar data from modern Portland cement mortars. The paper by Mr. Tucker traced briefly the development of reinforced concrete in this country, paying particular and deserved attention to the pioneer work of Mr. E. L. Ransome. As a practical contractor the author considered that the necessity of any longer exhorting upon the efficiency and reliability of reinforced concrete building construction had ceased to exist. Everybody now admitted its good qualities structurally. It was not admitted, however, that it would be handled satisfactorily architecturally. The development and perfection of this phase of reinforced concrete work was the task that now confronted engineers and architects. Prof. Newberry, in his report of the work being done by the Research Committee of the association, stated that careful studies into the significance of specific gravity determinations had determined the usefulness of this test in indicating the degree of burning of cement, and that now studies were being made to find a method of determination which would enable a quicker and easier testing of this property. He also called attention to the experiments now being made in Europe on the so-called ore-cements, that is, a Portland cement composed of lime, silica and oxide of iron, alumina being eliminated. In tests these cements had shown, as compared with cements containing alumina, an almost perfect resistance to attack by sea water. They also were uninjured by any amount of gypsum addition, thus making possible a cement and plaster mixture, not now possible, for stucco and hard finishing work. In conclusion it may be noted that the association in selecting its place of meeting gained two remarkable object lessons in the use of cement in the Marlborough Hotel Annex recently described in these columns, and in the new pier of reinforced concrete now being built at a cost of $1,000,000. We expect to present a description of this last structure in the near future.